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ABSTRACT

The middle school and high school lessons featured in this collection were crafted by science and math teachers who participated in a week-long seminar sponsored by the Eisenhower Professional Development Program administered by the Ohio Board of Regents. The lessons showcase a variety of active learning strategies from using hands-on, low-tech approaches to integrating high-tech, cutting-edge resources. Lesson topics include: (1) Investigating Energy Sources; (2) Probing the World of Energy and Its Conservation; (3) Fish Out of Water--Man Out of Land; (4) Are You Listening? (Noise Pollution); (5) Countdown to Population Explosion; (6) Hazardous Chemicals in Your Home!; (7) Water, Water Everywhere--How Much Is There to Drink?; (8) Water, Water Everywhere--But Not a Drop to Drink; (9) A Multi-Level Water Study; (10) Futuristic Fuel from Water; and (11) Acid Rain. (WRM)

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# ACTIVE LEARNING INSTITUTE:

# *ENERGIZING SCIENCE AND MATH EDUCATION*

## A Compilation of Lesson Plans

**Written by northern Ohio middle school/high school science and math teachers**

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## SUMMER INSTITUTE, 1998

**Global Issues Resource Center**
**Cuyahoga Community College East**
**Cleveland, Ohio**

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**Written by northern Ohio middle school/high school science and math teachers**

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# TABLE OF CONTENTS:


| | |
|---|---|
| Preface | i |
| Preface and Acknowledgements | ii |
| Investigating Energy Sources, Grades 7-8 | 1 |
| Probing the World of Energy and Its Conservation, Grades 7-12 | 21 |
| Fuels - Then and Now, Grades 11-12 | 25 |
| Fish Out of Water - Man Out of Land, Grades 9-12 | 34 |
| Are You Listening?, Grades 7-8 | 44 |
| Countdown to Population Explosion, Grades 6-8 | 64 |
| Investigating a Meadow (City Kid/Country Kid), Grades 6-7 | 75 |
| Hazardous Chemicals in Your Home!, Grades 9-12 | 90 |
| Water, Water Everywhere...How Much Is There to Drink?, Grades 6-8 | 99 |
| Water, Water Everywhere - But Not a Drop to Drink, Grades 7-8 | 109 |
| A Multi-Level Water Study, Grades 6-8 | 120 |
| Futuristic Fuel from Water, Grade 9 | 128 |
| Acid Rain, Grades 7-9 | 136 |

# PREFACE

Welcome to Active Learning: Energizing Science and Math Education! The lessons in this collection were crafted by science and math teachers who participated in a weeklong seminar sponsored by the Eisenhower Professional Development Program administered by the Ohio Board of Regents during the summer of 1998.

The **Active Learning Institute: Energizing Science and Math Education** showcased a remarkable variety of "active learning" strategies – from using low-tech hands-on approaches, to integrating high-tech cutting-edge resources. The powerful energy of the Institute resonates from the unique contributions of the **Collaborating Education Agencies:**

- Global Issues Resource Center
- Cuyahoga Community College
- Science, Engineering, Math, and Aerospace Academy at Cuyahoga Community College
- Educational Computer Consortium of Ohio
- Nature Center at Shaker Lakes
- National Teacher's Training Institute at WVIZ

Accomplishing a project of the magnitude of Energizing Science and Math Education requires participation by many dedicated people with a wide range of expertise in education, science, curriculum development, graphic design, marketing, and much more. The process of creating this collection has been an exciting one, and we have been fortunate to have worked with a wonderful group of people who, as we, believe in the project and dedicated their all to bring it to life.

The **Global Issues Resource Center's** staff: **Joanne Lewis**, Executive Director; **Dianne Smith**, Director of Education; **Heidi Makela,** Library Director; and **Vicki Zoldessy**, Office Manager shepherded each phase of the project from the "request for proposals" to the final reports.

The project had four primary collaborators for planning and presentation of the Institute events.

**The Nature Center at Shaker Lakes** staff: **Nancy King Smith,** Executive Director and **Karen Seymour,** Senior Naturalist.

# GLOBAL ISSUES RESOURCE CENTER

In the years since its inception in 1985, the Global Issues Resource Center has earned a national reputation for excellence. Its unique library collection and a wide range of educational programming and collaborations with other organizations meet the needs of a broad constituency. The mission of the Center is to foster citizen responsibility through development of a global perspective on the *sources and management of conflict, nuclear proliferation, and environmental and energy issues* through its multimedia library and creative programming. The Global Issues Resource Center has engaged over 26,000 students, educators, and lay citizens in the exploration of critical issues in the spirit of our motto: *We don't have to share beliefs, just a planet.*

The Global Issues Resource Center is located at the Eastern Campus of Cuyahoga Community College in Cleveland, Ohio.

# GLOBAL ISSUES RESOURCE CENTER LIBRARY

The library collection of the Global Issues Resource Center, which is open to the public, features materials in 17 subject areas and includes over 2000 books, 150 curricula, 60 periodicals, 400 videos, 500 games and simulation activities.

The Center's collection is accessible via CLEVNET, the electronic catalog of the Cleveland Public Library. Our materials may be requested through any CLEVNET library.

Annotated bibliographies are available for special subject areas and our catalogs of videos and simulation materials are valuable aids for teachers in their planning.

The Center has become recognized as a national clearinghouse of current, credible information and materials that are effective for use by educators at all levels. The wide range of resources and the Center's popular teacher training workshops and symposia form the basis for the Center's reputation as a valuable asset to teachers and students locally, regionally, and nationally.

**The National Teachers Training Institute at WVIZ Public Television**: **James Mathis,** Director of Educational Resources, **Oresta Zadony,** Project Director and three Master Teachers, **Donna Jeanne Nemeth, Harry Selner,** and **Ken Strauss.**

**NASA's Science, Engineering, Math, and Aerospace Academy** at Cuyahoga Community College staff: **Linda Darling,** Project Director, **Katherine Reed, Jondarr Bradshaw** and **Joan Borovick,** project instructors.

The **Educational Computer Consortium of Ohio** was represented by **Judith Brenneke,** Director, **Nancy Novak**, Coordinator Science/Math Discovery Lab, and **James Meinke,** Educator.

**Cuyahoga Community College**, home to the Center, provided in-kind support and use of its facilities. **Lawrence Simpson,** Provost Eastern Campus, and **Patricia Mintz,** Director of Faculty Development, provided project guidance. The **Technology Learning Center** under the direction of **Maria Arrington-Ferguson** hosted the Institute participants throughout the week to provide access to the technology of computers, computer peripherals, and the Internet. **Becky Kapley**, Associate Professor of Biology, was a presenter.

**Dr. John Settlage** of **Cleveland State University** provides pedagogical review and guidance and served as the professor of record for graduate credit for the week-long 1998 Institute session. **Dr. Margaret Brooks-Terry,** Department of Sociology at **Baldwin Wallace College** serves as the independent project evaluator.

**School Planning Personnel** for the project included: **Cleveland Public Schools:** Educational Leadership Awareness Network (ELAN); **Warrensville Heights Schools:** Mark Gray, Director of Accountability and Curriculum Development; **Cleveland Heights-University Heights Schools:** Elizabeth Shriver, Media Specialist, Roxboro Junior High; **East Cleveland Schools:** Robert Brownley, Assistant Principal.

**Janet Eby – Gilmour Academy**
**August Mancuso – Warrensville Heights Middle School**

**OVERVIEW:**

In this lesson students will investigate appropriate usage of line, circle and bar graphs while comparing the pros and cons of the three most commonly used non-renewable energy sources (coal, oil and natural gas) from an economic and ecological standpoint.

**PREREQUISITES:**

SKILLS: Addition, subtraction, multiplication, division, calculation of percentages, use of a protractor, grade level reading abilities.

KNOWLEDGE: Rudimentary knowledge of coal, oil and gas as sources of energy, familiarity with graphs.

**MATERIALS:**

Day 1: Dry erase boards and markers or large sheets of paper and markers (enough for six groups of students, 3 or 4 students to a group), graph paper, six protractors. Students will also need calculators.

Day 2: For each group of 3-4 students: 1 cookie containing chocolate chips, raisins and walnuts, 1 toothpick, paper plate or towel.

**ANTICIPATED STUDENT OUTCOMES:**

Students will be able to:

a. represent statistical information using bar, line and circle graphs
b. choose the appropriate graph for a given set of information
c. interpret graphically represented information
d. compare the pros and cons of the three most common nonrenewable energy sources (coal, oil and gas)
e. draw conclusions about the environmental impact of extracting these energy resources.

**CONNECTIONS TO PROFICIENCY TEST:**

Math: Read, interpret and use graphs to identify patterns, note trends and draw conclusions; solve problems and make applications involving percentages.

Science: Organize data, identify patterns and trends; Draw conclusions and/or recognize a conceptual model based on a given set of data; compare nonrenewable energy resources.

**INTRODUCTION:**

The introduction to this lesson will be given as a homework assignment the night before the lesson is to be covered. The assignment is in the form of two short readings with a question assigned to each reading. Total estimated time for this assignment is 40 minutes.

Reading 1: pages 4-7 in the history magazine for young people, "Cobblestone" volume 11, number 10, October 1990. Question: "What types of statistics (numbers) would energy researchers be interested in studying as they compare different energy resources?"

Reading 2: page 12 in "The Natural Gasbook" put out by the American Gas Association, 1515 Wilson Boulevard, Arlington, VA 22209. Question: "What three types of graphs are used in this reading?"

**EXPLORATION:**

This lesson is designed for two 90 minute blocks of time, although it may be completed in less time with students who are already somewhat proficient in graphing. For shorter class periods the timing will have to be adjusted accordingly.

**Day 1:** The lesson begins with a review of the three most commonly used types of graphs: bar, line and circle. Homework readings should be discussed and transparencies made from the blackline masters shown. Focus on what type of information is best illustrated with each kind of graph. For example, line graphs are most commonly used to show how statistics change over time. Bar graphs compare numbers from different sources and circle graphs or pie charts show percentages of a whole. Be sure students are clear on this point. Showing segments of the video "Math Media Video: Graphs" available from WVIZ (20 minutes) will help reinforce this information.

Next, have students complete the included worksheet which allows students to practice making graphs from real statistics. Students may be divided into groups of three or four to complete the worksheet. When students are done, have them compare their answers by writing them on the board or showing the graphs drawn on a large sheet of paper. Did all students graph the information appropriately?

Homework: Reading 3: Present the following homework assignment as a challenge: "Can you create a line, a bar and a circle graph to illustrate the statistics given in this reading?" This reading was copied from an American Coal Foundation publication entitled "COAL: Ancient Gift Serving Modern Man". Copies may be obtained from the American Coal Foundation, 1130 Seventeenth Street, N.W., Suite 220, Washington, D.C. 20036-4604.

**Day 2:** Begin the class by showing clips from Bill Nye The Science Guy's video entitled "Energy" (number 145 available from WVIZ) to give some background information about fossil fuels. FOCUS: Which type of fuel extraction is most damaging to the earth?

The activity for day 2 was copied from a book entitled Energy Issues: Fossil Fuel Extraction. It may be reviewed in its entirety in "background Information" section of this lesson plan.

In this activity the students will extract chocolate chips, raisins and walnuts from a cookie to simulate mining coal and extracting oil and natural gas from the earth. The students should do this as carefully as possible so as to preserve as much of the cookie (representing the earth) as possible. If this were to be presented as a science lesson, I would have the students weigh their cookie on a balance scale before mining out the resources (chips, raisins and nuts), and then have them weigh the mined resources individually afterwards so that they can calculate exactly how much of the cookie (earth) each resource represented. Once the students have completed the activity, have them draw a circle graph showing how much of the weight of the cookie was made up of each individual resource. Depending on the math skills of your students, it may be advisable to review how to calculate percentages and how to draw an accurate circle graph.

**DEBRIEFING:** (15 minutes) Hand out copies of the utility bills provided. You may wish to copy some of your own utility bills as well for comparison's sake. Be sure to delete your personal information such as name, address and account number before making copies.

Ask students:

1. To compare the presentation of the information on each bill.
2. How is the graph on the electric bill helpful to the customer?
3. Should the gas bill include a graph also? What type?
4. Could other information on these bills be presented using different types of graphs?
5. Why are graphs so useful when presenting statistical information?

**EXTENSIONS:**

1. Compare U.S. energy consumption to energy consumption in 5 other countries. Use the internet or the library to obtain this information. Represent this information using a bar graph and display it in the classroom.

2. Draw a poster showing projected energy usage in the U.S. over the next 50 years. Use a line graph to illustrate this information.

3. Draw a pie chart (circle graph) to show the percentage of electricity generated from each of the following sources: oil, coal, natural gas, nuclear, hydroelectric, solar and other sources. List 5 ways to save electricity.

**RESOURCES:**

**Books**: The Natural Gasbook, American Gas Association, 1515 Wilson Blvd. Arlington, VA 22209.
Coal: Ancient Gift Serving Modern Man, American Coal Foundation, 1130 17th St. N.W. Suite 220, Washington D.C. 20036
SIRS Digest: Energy, Eleanor Goldstein, Global Issues Resource Center.
Environmental Science Activities Kit, Michael L. Roa. Published by The Center For Applied Research In Education, NY, 1993. Available in the Global Issues Resource Center at Cuyahoga Community College, Eastern Campus, Cleveland, OH.

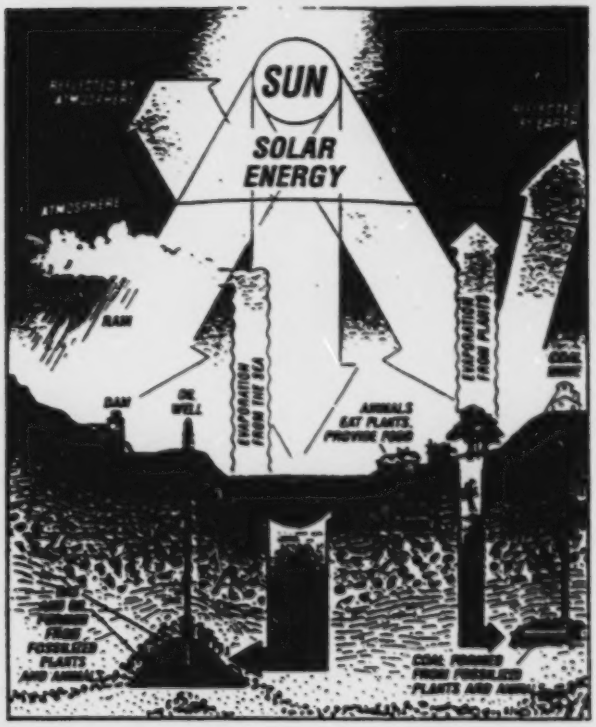
**Articles**: "From the Crow's Nest: Energy: Powering a Nation" in Cobblestone magazine, Volume 11, number 10, October 1990.

**Internet**: http://ericir.syr.edu/
http://chi.hearth.com/addcalc.html
http://www.naturalgas.org

**Video**: All the listed videos are available from the WVIZ video tape library, 4300 Brookpark Rd., Cleveland, OH 44134. 216-398-2800
Mathmedia video: Graphs
Bill Nye the Science Guy: Energy
3-2-1 Classroom Contact: Generating Electricity: More Power

Sometimes you feel as though you are full of energy. Other times you are so tired you say, "I don't feel like playing; I don't have the energy." What is this mysterious thing we call energy?

Energy is what we need to move and to get things done. Scientists say that energy is the ability to do work. Both machines and people need energy. We use energy when we ride a bike, throw a ball, or think about a math problem. Cars, toasters, and computers also use energy.




*The sun is the origin of most of the energy we use.*

Another way to think about energy is to think about change. Anything that changes is using energy. When a pitcher throws a baseball, the ball changes position and uses energy. When an acorn grows, changing from a seed to a tree, it uses energy. When you cook an egg for breakfast, heat changes it from being clear and runny to being white and firm. Heat is energy. Where does the energy for all these things come from? Surprisingly, almost all of it comes from the sun.

Energy that people use comes from the food they eat—everything from broccoli to fried chicken. Broccoli grows because it can absorb sunlight and convert light energy into food. Chickens grow because they eat grain, which comes from plants. Thus, everything that lives gets its energy either directly or indirectly from the sun.

Machines get their energy from fuels such as coal, oil, gas, and wood. These fuels store energy that originally came from the sun. Trees store the energy of the sun in wood. Coal, oil, and gas were formed millions of years ago from the remains

continued



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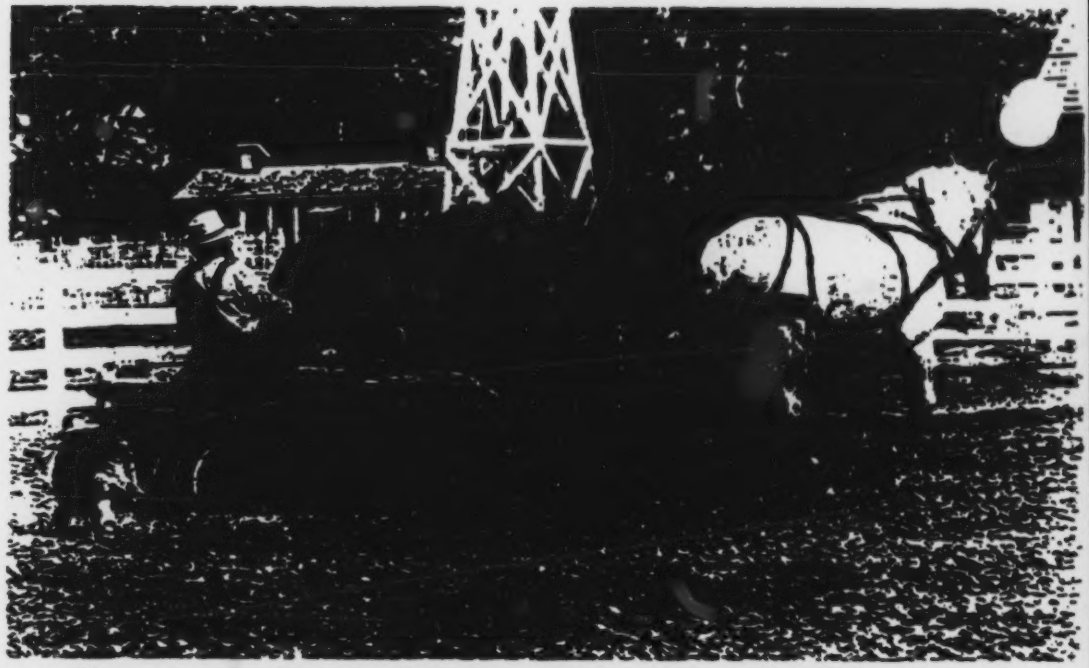

*Horsepower was one of the first energy sources people harnessed. Today horsepower is a unit for measuring power produced. The term was coined by Scottish inventor James Watt, who determined that a horse could do 33,000 foot-pounds of work per minute in drawing coal from a pit.*

of plants and animals.

Other sources of energy include wind turbines and hydroelectric dams. But the energy in the wind and in flowing water also comes from the sun. The wind blows because different parts of the earth absorb sunlight and heat up differently. When one part of the earth is warmer than another, the warm air rises and the cooler air flows in to take its place. We call this moving air wind.

Water flows in streams and rivers because of the sun. Think about where rain comes from. The sun warms water on the surface of lakes and oceans, causing it to rise in the air and form clouds. When rain falls and hits the ground, water begins to flow. It flows down mountains and hills. The energy of moving water can be captured by hydroelectric dams, but the electricity produced comes from the energy in sunlight.

Energy is found in many forms. There is energy in light and in heat, in electricity and in food. We cannot make energy, but we can change it from one kind to another. For example, when we eat food and then go out to run, we change the energy that was in the food into the energy of movement—we can take a hamburger and milk shake and

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turn them into a baseball game or a bike ride. A microwave oven turns electrical energy into heat. A light bulb converts electrical energy into light. A car engine changes the energy stored in gasoline into the energy of movement. A radio converts the chemical energy in batteries into sound.

Sometimes energy is stored. Water behind a dam is stored energy. When water is allowed to flow past the dam's turbines, it produces electricity. Batteries store chemical energy. If we connect a battery to a circuit, electricity flows through the wires. Do you have any wind-up toys? When you turn the crank, you are storing energy in a spring. When you release the toy, you let the energy out of the spring. Stored energy is called potential energy because it is waiting to be used.

Many different forms of energy were used to build our country. In the beginning, colonists used their own muscle power, burned wood, and harnessed rivers. Today we burn oil, gas, and coal, split atoms, and capture the sun's energy directly. We run factories; power cars, trucks, and tractors; heat our homes; and communicate through telephones, television, and computer systems. Energy for those uses comes mostly from sources that have been developed in the past one hundred fifty years. Fossil fuels (oil, coal, and gas) are our greatest source of energy today.

In the past few decades, Americans have begun to realize that fossil fuels are nonrenewable—that is, we will run out of them someday. The continued use of fossil fuels and a more recently developed energy source, nuclear power, also has been challenged by those who believe that they have damaging effects on the environment. New energy sources are now being explored, and new technologies are now being developed for using and finding more old energy sources.

*One of the most recently developed energy sources is nuclear power. The Trojan power plant in Oregon is one of 112 nuclear facilities now operating in the United States.*

As researchers develop new technologies, they also must consider whether an energy source is renewable, what it costs to obtain and use it, and what effects using it will have on the environment. In this way, America's energy story continues to be one of discovery and innovation.



Question: What types of statistics (numbers) would energy researchers be interested in studying as they compare different energy resources. Give 3 examples.

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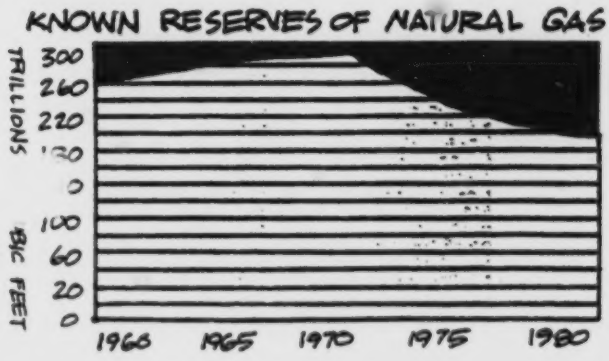
# Supply and Demand

Today, experts estimate there are about 200 trillion cubic feet of natural gas in proved reserves in the United States. Proved reserves are gas deposits known to be underground that can be produced using today's methods and machinery. Adding Canada and Mexico's proved reserves brings the total to more than 360 trillion cubic feet in North America.

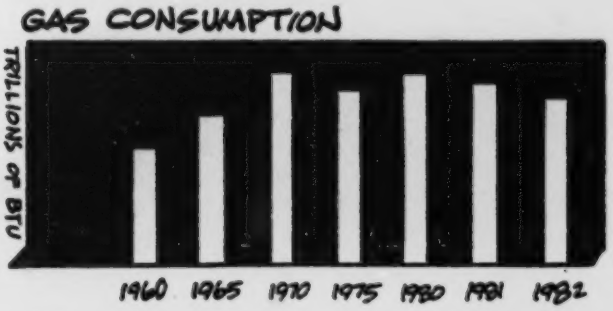
Of course, these figures do not include natural gas deposits that have not yet been discovered. Some scientists estimate the potential for future gas discoveries to be up to 10 times today's proved reserves.




We know that in the United States we use between 17 and 18 trillion cubic feet of natural gas each year. So, you might expect the total amount known to be in the ground to be shrinking. But, in fact, new discoveries help to make up for the gas that is being used, so that total reserves have changed very little in recent years. And in Canada and Mexico, the proved reserves are growing.

For a long time natural gas prices were kept low by government regulation. The low price encouraged the use of natural gas, so that U.S. consumption increased each year up to the early 1970's. As a result, we began using more gas than we were finding. Finally, there was a shortage of supply in some areas, and many people began worrying about running out of natural gas.

When this happened, the government allowed prices of natural gas to go up so that companies would be willing to explore and produce gas from deeper within the earth and in less accessible places. The higher cost of gas (as well as of other forms of energy) encouraged people to conserve energy even more. If you will look at the chart labelled "gas consumption," you will see that the use of natural gas dropped between 1975 and 1982. Since producing companies now have more gas available than people are using, there is plenty to go around, and people a beginning to use more. But the overall consumption is still well below that of the early 1970's.

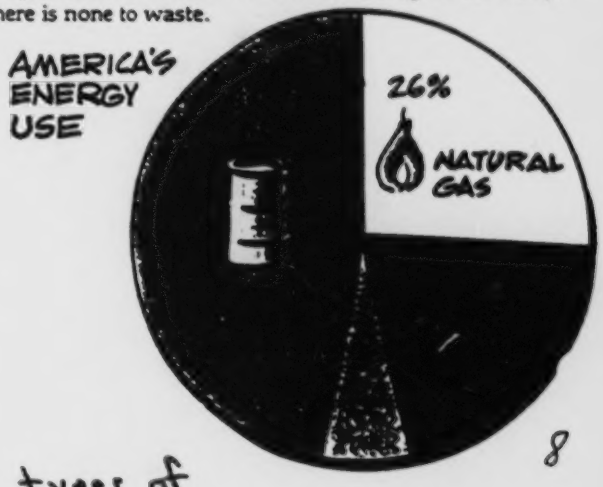



Although nobody knows for sure what will happen in the future, experts expect the use of natural gas to continue growing, at least through the year 2000. The three lines in the chart below show three estimates of future natural gas use. The top line is a high estimate. The bottom line is a low estimate. The line in the middle shows the moderate growth which most gas industry experts believe is most likely.

Most people familiar with natural gas supply and demand think it will continue to be an important source of energy, along with electricity, coal and oil.

But even though we may continue to find more deposits, sooner or later we will be using natural gas faster than we find it.

That's why it is important to conserve energy. Not just natural gas, but all of our resources. There is enough to use wisely. But there is none to waste.

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Question: What are the three types of graphs used in this reading?



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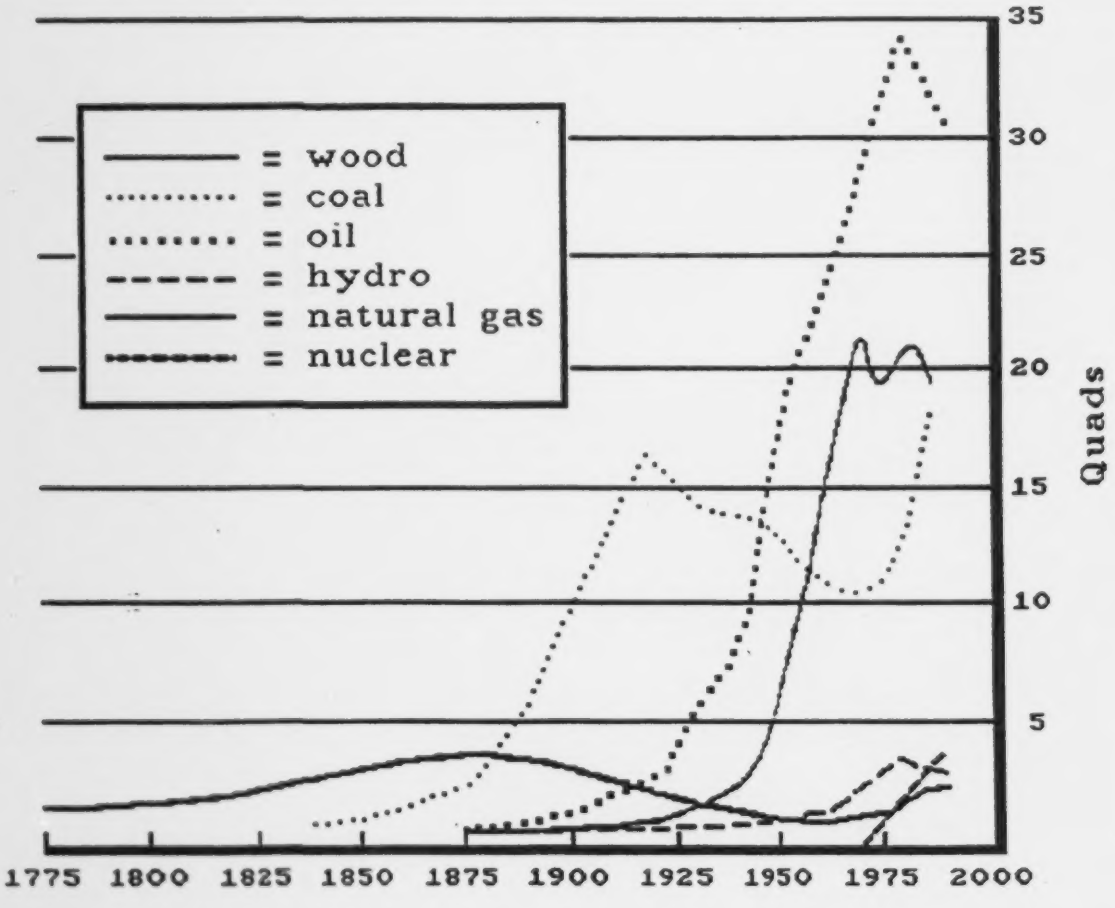
Graphing
Transparencies

# U.S. Historical Energy Mix

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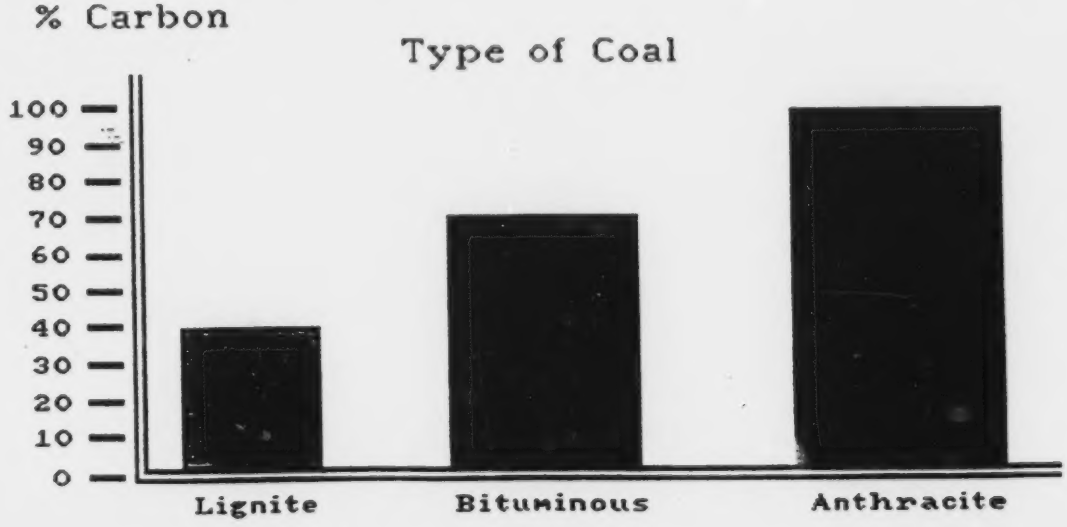
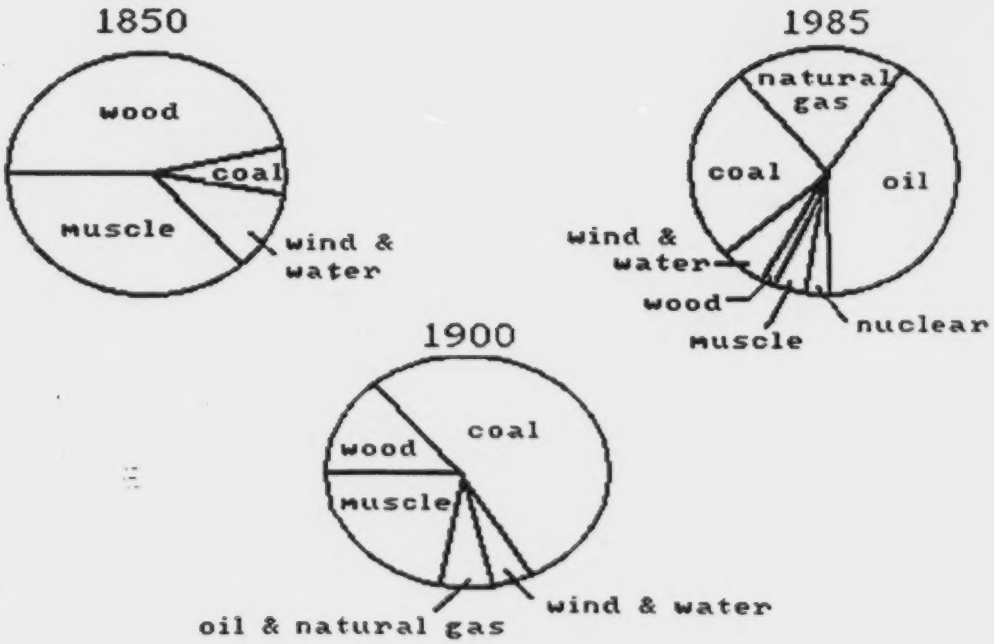

% Carbon
Type of Coal
100
90
80
70
60
50
40
30
20
10
0
Lignite
Bituminous
Anthracite

10

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SCIENCE/MATH LESSON
PROBLEM

You have a choice of heating your home with the energy sources listed below;

a) electric furnace b) oil furnace c) natural gas furnace.

The amount of usage and cost per month of each type of fuel is listed in the table below.

1) Decide which fuel is the best cost value per month (show calculations).
2) State in writing the effect fuel usage has on the environment.
3) Draw a bar or line graph showing the information in the table.

| oil furnace | electric furnace | natural gas furnace |
|---|---|---|
| 70 gal @ $1.95 per gal | 108 KWH @ $1.13 per KWH | 115 CCF @ $0.97 per CCF |

1.

2.

3.

12

Reading 3: Homework to be assigned after the first day of the lesson.

Challenge: Can you draw all 3 types of graphs discussed in class using the statistics below?

# 27 Coal-mining States

Although 90 percent of the country's coal reserves are concentrated in 10 states, coal is mined in 27 states and can be found in even more. Montana has the most coal, 25 percent of demonstrated reserves. Wyoming, third among states with the most coal, is first in coal output, accounting for 18 percent of annual production.

U.S. coal reserves contain 12 times as much energy as all the oil in Saudi Arabia! A brief look at some numbers explains why coal is the country's most abundant and important energy resource.

According to the United States Geological Survey, we have 1.7 trillion tons of identified coal resources—coal for which geological evidence and engineering studies provide reliable information about location, rank, quality and quantity. (Geologists recognize that more coal deposits are likely to be discovered in the future, so they estimate total coal resources could amount to 4 trillion tons.)

Much of the coal we know about cannot be mined today, because it would be too costly or existing technology doesn't allow it. It may be too deep, for example, or the quality may not meet current needs. So to be realistic, experts estimate that 472 billion tons of that coal are potentially recoverable. This is called the demonstrated reserve base.

Mining techniques leave a good deal of coal in place, so the amount of coal that experts estimate actually can be mined is called the recoverable reserve base. It amounts to an estimated 267 billion tons—29 percent of the entire world's recoverable coal!

**WHERE THE COAL IS LOCATED**

| State | Billion Tons | Percent of U.S. |
|---|---|---|
| Montana | 120 | 25.4 |
| Illinois | 78 | 16.5 |
| Wyoming | 68 | 14.4 |
| West Virginia | 37 | 8.0 |
| Kentucky | 30 | 6.3 |
| Pennsylvania | 29 | 6.1 |
| Ohio | 19 | 4.0 |
| Colorado | 17 | 3.6 |
| Texas | 13 | 2.7 |
| Indiana | 10 | 2.1 |
| Other states | 51 | 10.9 |
| TOTAL | 472 | 100.0 |

*A stacker-reclaimer places incoming coal on a stockpile at the rate of 1,500 tons an hour. Later, when the coal is needed, the bucket wheel reclaimer will pick it up again. The machine moves on rails the length of the 1,200-foot stockpile.*



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Lesson for Day 2

Name _____ Class _____ Date _____

## 22.2 Fossil Fuel Extraction: Instructions and Data

Your teacher will provide you with a cookie. This cookie represents a land area that may contain deposits of coal (represented by raisins), oil (represented by pieces of nuts), and/or natural gas (represented by chocolate pieces). You will also be provided with a toothpick, which represents the mining and drilling equipment used in obtaining the coal, oil, and natural gas.

Your job is to try to remove as much of the coal, oil, and natural gas as possible with as little damage to the environment as possible.

Imagine that the top surface of the original cookie is an area of land on which various kinds of plants and animals live.

In the space below, sketch the cookie surface before and after "mining."

Also, record the amounts of the various resources that you were able to obtain and the amount of "waste" generated. (**Estimate:** about _____% of the original cookie.)

**BEFORE MINING**

**AFTER MINING**

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resources recovered (as % of the original cookie):

_____% coal (raisins)

_____ % natural gas (chocolate)

_____ % oil (nut pieces)

_____ % waste (crumbs and pieces)

On a separate piece of paper draw a circle graph to show the above percentages.

14

Name _____ Class _____ Date _____

## 22.3 Fossil Fuel Extraction: Questions

1. What are some problems associated with obtaining and using coal?

2. What can be done to reduce or avoid these problems?

3. What are some problems associated with obtaining and using oil?

4. What can be done to reduce or avoid these problems?

5. How can saving electricity help reduce the need for mining and shipping coal?

6. List some ways that you could reduce your electricity use.

7. How can reducing gasoline consumption reduce the need for mining, shipping, and refining oil?

8. List some ways that you could reduce the need for oil?

9. What are some advantages and disadvantages of natural gas as an energy source?

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15

the Illuminating Company

# ELECTRIC SERVICE STATEMENT

Account Number: [redacted]

Service for:

Your Bill is calculated as Follows:

| | | |
|---|---|---|
| PREVIOUS BALANCE | $111.28 | |
| PAYMENTS AS OF 05-11-98 | 111.28- | |
| UNPAID BALANCE | | $0.00 |
| RESIDENTIAL RATE | 101.09 | |
| THIS MONTH'S CHARGES | | $101.09 |
| **PLEASE PAY THIS AMOUNT** | | **$101.09** |

METER NUMBER 24045
ACTUAL 05-09-98 57211
PRIOR 04-08-98 56336

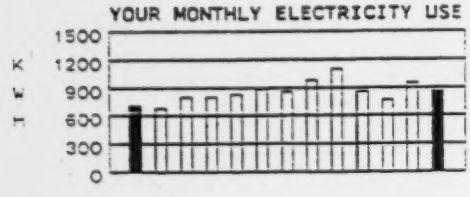
KWH USED IN 31 DAYS 875

ANY UNPAID BALANCE AT YOUR NEXT BILLING DATE IS SUBJECT TO A LATE PAYMENT CHARGE OF 1.5%

DUE DATE FOR CURRENT CHARGES: 05-26-98
THANK YOU FOR YOUR PAYMENT

Third Federal S&L & Loan Assoc. MAY 16 '98 Teller 02-13

YOUR MONTHLY ELECTRICITY USE




AVERAGE COST PER DAY WAS $3.26

FUEL COST @ ¢1.3183/KWH CUST CHARGE = $4.75

**FOR YOUR INFORMATION** PLEASE SEE THE ENCLOSED BILL INSERT FOR DETAILS CONCERNING THE MEDICAL CERTIFICATION PROGRAM.

IF PAYING IN PERSON PLEASE PRESENT ENTIRE BILL

## COLUMBIA GAS

of Ohio

P O BOX 1038
LORAIN OH 44055

FOR QUESTIONS OR INQUIRIES PLEASE HAVE YOUR ACCOUNT NUMBER AVAILABLE AND CALL
MON-FRI 7:30 AM TO 10:00 PM AT 800-344-4077
SAT,SUN 8:00 AM TO 4:00 PM

RESIDENTIAL

10

RATES AND EXPLANATIONS AS TO THEIR APPLICATION ARE AVAILABLE UPON REQUEST.

NAME AND SERVICE ADDRESS

| CUSTOMER ACCOUNT NUMBER [redacted] | | |
|---|---|---|
| PAST DUE AFTER | PAY THIS AMOUNT | CODE |
| MAR 2, 1998 | 98.78 | |

GAS USAGE (METER NO. 756004)

| | | |
|---|---|---|
| TO FEB 12 ACTUAL READING | 6832 | |
| FROM JAN 14 CALCULATED | 6666 | |
| TOTAL USED (29 DAYS SERVICE) | 166 | CCF |
| NEXT READING DATE: APR 14, 1998 | | |

ACCOUNT SUMMARY

| | $ |
|---|---|
| PREVIOUS BALANCE | 129.04 |
| PAYMENTS RECEIVED | 129.04 CR |
| BALANCE AT BILLING | .00 |
| CURRENT BILLING | 98.78 |
| PRESENT BALANCE | 98.78 |

CHARGES INCLUDE GAS COST RECOVERY OF $60.96 AT THE RATE OF $.36724 PER CCF.

MESSAGES

Your prompt payments are appreciated. We thank you.

The top part of this sheet is an electric bill. The bottom part is a gas bill. Which bill is more user-friendly? Why?



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Background information for second day of lesson.

## ACTIVITY 22: FOSSIL FUEL EXTRACTION

### Activity Summary

Students "mine" cookies containing raisins, nuts, and chocolate as a simulation of mining for coal, oil, and natural gas.

### Introduction

Often, when we discuss saving resources, we think only of saving that particular resource itself. We think of saving oil or electricity or water or trees. It is important to realize the interconnectedness of various resources. For example, when we reduce paper use, we are also reducing water and air pollution, saving habitat for many kinds of plants and animals, saving energy, protecting watersheds, and reducing erosion. When we reduce fossil fuel use, we also reduce air pollution and water pollution and protect habitats. In this activity, students "mine" cookies or brownies to obtain raisins, nuts, and chocolate from within. This serves as a model for removing fossil fuels from the Earth and points out that the removal of fossil fuels has a great impact on the environment.

While this activity is simple and fun, it is useful as a reminder to students that wasting energy has many effects beyond the wasted energy itself.

### Grouping

Individual or teams of 2–3, depending on how many cookies you want to make.

### Time

45–55 minutes

### Anticipated Outcomes

The students will:

- increase their understanding of the environmental impacts of mining for fossil fuels or other Earth resources.
- increase their willingness to reduce energy and other resource waste.

### Materials

—Photocopied student pages:

- 22.1 Fossil Fuel Extraction: Background Information (one per student)
- 22.2 Fossil Fuel Extraction: Instructions and Data (one per student or team)
- 22.3 Fossil Fuel Extraction: Questions (one per student)

—Per individual or team of 2–3 students:

- 1 cookie containing chocolate chips, raisins, and walnut pieces
- 1 toothpick
- 1 saucer or small plate

17

### Vocabulary

crude oil
fossil fuel
fractional distillation
nonrenewable resource
strip mining

### Teacher Preparation

1. Photocopy the Background Information sheet (22.1), Instructions and Data sheet (22.2), and Questions sheet (22.3).
2. Obtain materials for baking cookies and bake them. Use whatever recipe you like, making at least one cookie per student or team of students. (You might work something out with a home economics teacher to get the cookies baked.)

> **SAFETY CONSIDERATION**
>
> Caution the students not to eat cookies that other people have handled. (You might consider providing some sort of snack to be eaten after the activity. This should reduce the temptation of the students to eat the cookies.)

### Procedure

1. Either bake the cookies or arrange to have them baked.
2. Distribute the Background Information sheet and have the students read and discuss it.
3. Distribute the Instructions sheet and discuss the procedures to follow.
4. Distribute the cookies and toothpicks (on saucers, rather than on paper towels or napkins).
5. Have the students "mine" their cookies, recording their data.
6. Discuss the activity.

### Discussion

1. What happened to the "land" (represented by the cookie) when you mined for the fossil fuels?
2. Were any crumbs spilled on the floor or table? What is erosion?
3. What would happen to the plants and animals that lived on land that was mined in this way?
4. What could be done to reduce the damage done to the environment by such mining?
5. If we use less energy, we need less fossil fuel. If we need less fossil fuel, we don't need to do so much mining. What can you do to reduce energy use?

### Answers to 22.3, Fossil Fuel Extraction Questions

1. Coal is a nonrenewable resource. Surface mining coal severely disturbs the land and the plants and animals that live there. Underground mining and surface min-

18

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ing both produce water pollution. Underground mining is very dangerous. Burning coal produces air pollution, acidic precipitation, and water pollution.

2. Since much coal is used to produce electricity, saving electricity will reduce the need to mine and burn coal. Supporting the passage of strict pollution control laws will help. We need to be willing to pay for the costs of reducing pollution.
3. Oil is a nonrenewable resource. Oil spills can and do occur when oil is mined, transported, and used. Burning oil produces air pollution and contributes to acidic precipitation and water pollution.
4. Anything that we do to save electricity also helps reduce the need for oil. Since so much oil is used for transportation, especially private automobiles, driving less, keeping cars tuned properly, using more fuel-efficient cars and many other transportation-related changes of behavior can help. Supporting the passage of strict pollution control laws will help. We need to be willing to pay for the costs of reducing pollution.
5. Electricity production is the main use for coal in the United States. Saving electricity means less coal will need to be mined and burned.
6. There are many ways to reduce electricity use. Reducing space heating and air conditioning, water heating, and lighting uses are important. See Activities 17, 18, and 19.
7. See question 4.
8. Saving electricity, driving less, supporting public transportation, recycling used motor oil, and many other things can save oil.
9. Natural gas is a nonrenewable resource, and burning it produces some air pollution. It burns much cleaner than other fossil fuels and gives a lot of heat when it burns.

**Extensions (See Activity 32 for suggestions for student projects.)**

1. This activity is similar to Activity 1, Surface Mining. If you have not yet done it, consider doing it after doing this one.
2. Activity 10, Oil Spill!; Activity 14, Acidic Precipitation; and Activity 15, Global Warming, are also closely related to this activity.
3. Visit a local mine and find out about measures taken to reduce environmental damage.
4. Write to coal and oil companies or organizations to find out about environmental protection measures they take. See Activity 25 for some addresses.
5. To understand fractional distillation, make a mixture of alcohol and water. Have the students distill off the alcohol by heating the mixture to about 80°C.

**Modifications**

1. Rather than individual cookies, make a pan of brownies. This enables you to bury the nuts, raisins, and chocolate chips deeper.
2. Rather than chocolate chips, use candy-coated chocolate pieces such as M&M's.®
3. Use only chocolate pieces, and have the students keep track of how many chips they successfully remove. (One chip represents a community's energy needs for one

19

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week.) Point out that energy is used in the "mining" process, and it takes time, energy, and money to restore the land. Students can be "charged" chocolate chips based on how much damage they do to the land. For example:

| | |
|---|---|
| Cookie still in one piece, relatively undamaged: | 1 chip charged |
| Cookie in 2–3 pieces: | 2 chips charged |
| Cookie in more than 3 pieces: | 3 chips charged |
| Cookie in crumbs: | 5 chips charged |

## References

Anonymous, *If the Earth Were a Cookie*. Washington, DC: National Science Foundation, 1991.

Miller, G. Tyler, *Living in the Environment*. Belmont, CA: Wadsworth Publishing Company, 1990.

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**Laurie Hance** - Newbury High School, Newbury, OH

## OVERVIEW:

Students will participate in this lesson because it will encourage the learning and comprehension of Life Math Skills (satisfying IEP Transition objectives) and reinforce, as well as integrate, Math Calculation skills ( IEP objectives). The approach is multi-sensory, thus aiding attention as well as short and long term memory. Students will increase their knowledge bank to further link math information and skills.

## GOALS:

Students will increase math skills through the investigation of Energy sources and Energy conservation.

## PREREQUISITE:

**Skills:** Multidigit addition, subtraction, multiplication and division.

**Knowledge**: Visual sequential guided formats, use of calculator.
ITV Series: "Energy: The Keynote to Our Future" ID No. 0002100120308, videocassette set. Global Issues Resource Center, Cuyahoga Community College.

## MATERIALS:

-calculators(1-3)
-video(artifact 1c)
-Scriptographic Press booklets(1-4)(artif. 1b)
-Internet Lesson (1-3)(artif. 1a)
-worksheets (1-3)(artif. 1e)
-experiment worksheets(1-3)(artif.1f)
-cumulative tests(1-3)(artif. 1g)

## ANTICIPATED STUDENT OUTCOMES/OBJECTIVES:

The students will:

1. Students will review multidigit addition, subtraction, multiplication, and division, in order to calculate energy usage.

2. This lesson will help further practice of mathematical skills and discover their interrelationship and relevance to everyday life.

3. Students will learn metric prefixes in order to use them to convert information into metric measurement (artifact 1a).

4. Students will read together and share orally needed pre-activity information through the use of Scriptographic Press booklets (artif. 1b).

5. Students will view video before (vol. 1&2) and after (vol. 3&4) in order to visually observe pre-activity information and motivate interest(artif. 1c).

6. Students will monitor and record the usage of energy in their homes through data analysis and math calculation onto worksheets (artif. 1e).

7. Students will perform an experiment by monitoring energy through fruit.

8. Students will investigate energy conservation through viewing conclusion of video(artif. 1c,vol. 3&4) as a post-viewing activity.

## CONNECTIONS TO PROFICIENCY TEST:

1. Evaluate principles of energy usage and its applications.
2. Apply conceptual and mathematical models, and theories to explain and predict the interactions of components in systems.
3. Choose appropriate information and solve a problem quantitatively.
4. Given information such as physical and chemical properties, determine the best material for a given application.
5. Predict the effect on an ecosystem due to a given or proposed environmental change, specifically conservation methods.
6. Analyze data to identify patterns and trends and draw appropriate conclusions.

## INTRODUCTION:

1. Read together and discuss scriptographic booklets. (artif.1b)

2. View video vol 1&2. (artif. 1c)

3. Check for understanding through use of sequential organizer after each of the following resources is displayed: Fossil fuels, Hydroelectric power, Wind energy, and Photovoltaic energy (artif. 1d. p. 59).

4. Discuss other energy resources not on worksheet.

## EXPLORATION:

1. Have students record and calculate their own home usage of energy through data analysis worksheets. (artif. 1e).

2. Do in-class hands-on experiment using energy from fruit. (artif. 1f)

3. Have students take cumulative multiple choice test to check for understanding (tests must be read to students) (artif. 1g).

## DEBRIEFING:

1. Have students view video, vol 3&4. To understand how they can take action to help conserve energy.

2. Use worksheets theme 1V-28 and 1 to self-check their energy conservation as a follow-up to the lesson.

## EXTENSIONS:

1. Have students monitor, record, and calculate their own electric or gas meters at home.
2. Field Trip: Great Lakes Science Center, 601 Erieside Av., Cleveland, OH, ph. 216-694-2000.

## Resources:

Conserve and Renew: An Energy Education Activity Packet for Grades 4-6, California Energy Extension Service, 1990.

"Energy Choices for the Future," A Traveling Teaching Unit, 2nd Edition, Global Issues Resource Center, Cuyahoga Community College, Cleveland, OH 44122, 1995.

"Let's Learn About Energy and the Environment" and "How About Electricity?", Channing L. Bete Co. 1-800-628-7733.

**Video:**

"Energy: The Keynote to our Future"

**Internet:**

http://www.King'sK12.ca.us/math/welcome.html

Joan Drobnak - North Olmsted High School
Joseph Porostosky - Lake Catholic High School

## OVERVIEW:

The intent of the lesson is for the student to identify and analyze current and future sources of energy and evaluate the environmental hazards of each energy type. The students will initially identify primary sources of energy through class brainstorming, then analyze one of the eight main sources. The cost and environmental aspects will be researched through pamphlets, the Internet, and various other sources. The students will then create a presentation of their energy source. New student groups will determine which energy source is best for a particular type of community and make a presentation to the class. The final stage of this project is to identify and discuss future sources of energy through a class discussion.

## PREREQUISITE:

Skills: Interpret graphs, basic research skills, graphing, unit conversions, computer internet skills.

Knowledge: chemistry, algebra

## MATERIALS:

whole class: Fuel Clue Cards, globe, media center, Internet capable computers (optional)

Per group (3A students): specific fuel information packets, white boards, markers, erasers, handouts

## ANTICIPATED STUDENT OUTCOMES:

The students will:

1. identify and analyze primary sources of energy, cost, availability, environmental impact
2. determine the best energy form to use in a particular community based on economic and environmental issues
3. predict the future uses and sources of fuels

**CONNECTIONS TO PROFICIENCY TEST**

**12th grade Science Outcomes:**

1. Trace and evaluate energy transformation and/or apply the principles of mass/energy conservation to a physical system.
2. Apply laws, conceptual and mathematical models, and theories to explain and predict the interactions of components in systems.
3. Choose appropriate information and solve a problem quantitatively.
4. Given information such as physical and chemical properties, determine the best material for a given application.
5. Predict the effect on an ecosystem due to a given or proposed environmental change.
6. Identify the advantages and disadvantages of certain materials, practices or processes given appropriate information.
7 Analyze data to identify patterns and trends and draw appropriate conclusions.
8. Identify procedures to test a hypothesis and select necessary equipment.

**INTRODUCTION:** 1/2 class period (30 minutes)

I. The class will brainstorm on primary sources of energy. The eight main sources (teacher information): nuclear, solar, wind, hydro, gas, oil, coal, geothermal (local: heat pump, global: natural sources like Old Faithful).

II. Hand out one Fuel Clue Card per student. Instructions included on Fuel Clue Cards handout. Have the students arrange themselves into eight groups according to like characteristics. Each group will have six different clues to determine what fuel type they have. Review.

**EXPLORATION:** class periods (45-100 minutes)

The class will be divided into groups of 3-4 students. Each group will choose a number that is correlated to one of the eight primary sources of energy listed above. Allow the students to select the number, but do not initially tell them what number is correlated to what energy source. Each group will research the source of energy through packets of information in the classroom, textbooks and reading materials from the media center, and various Internet sites. A list of Internet sites will be available for student exploration; the students may find other sites. The following questions need to be answered:

A. What are the general locations and sources of the energy? How easy is it to procure and transport the energy source? Justify your answers.
B. What is the cost per unit of the energy (in the unit that it is most commonly sold in, e.g. kwhr, BTU, Joules)
C. What is the cost per unit in joules? Include a conversion table.

D. What are the environmental concerns? Local vs. Global. Production, transportation, after use contaminants, hazards to workers, possible leaks/spills, and other forms of pollution. What would happen if the energy plant was heavily damaged (tornado, low water, fire...)?
E. A presentation of the findings will be given to the class (5 minutes/group) on white boards, overhead transparencies or other form.

**DEBRIEFING:** 3/4 class period (20-30 minutes)

I. The class will reconvene and discuss the findings from the exploration. Any questions will be answered.

II. The class will determine which sources are used locally, which sources are most popular locally, and where the eight energy sources come from. (solar - sun)

III. New groups will choose a number between I-8nd the number will be correlated with a geographic location throughout the world. Each group will then recommend a form of energy that will best be suited for the location. A presentation of the findings will be given to the class (3 minutes/group). The following areas are suggested: Moscow, Hawaii, France, Antarctica, Northern California, Alaska, Australia, North Africa.

IV. Class discussion on appropriateness of group choices.

**EXTENSIONS:** 1/4 class period (10-15 minutes)

I. The class will reconvene and brainstorm on future sources of energy. what sources may be used more commonly, used less commonly; what are some possible new sources of energy. Possible sources: tidal waves, more efficient solar, liquid hydrogen (Lake County public transportation currently uses this in a few buses), alcohol.

II. Apply new sources locally and globally. How might these new sources affect the world as it currently exists? Assignment: Write a 2-3 paragraph news article that could appear in the science section of the newspaper in the year 2015 concerning one of the new sources of fuel OR write a letter to the editor explaining why your fuel type is important to your community.

Four handouts are included:

1. Exploration.
2. Debriefing sheet I
3. Debriefing sheet2
4. Extension handout

## TEACHER BACKGROUND INFORMATION AND RESOURCES:

The teacher needs to be familiar with the sources of energy. These resources can be a combination of print materials, Energy Unit Binder (group of energy pamphlets and Internet resources), www addresses as listed below.

### Books:

Alternative Energy Sourcebook. A Comprehensive Guide to Energy Sensible Technologies. Real Goods Trading Corporation. 1993

Annual Energy Outlook with Projections to 2010. Energy Information Administration, 1992.

Cool Energy: The Renewable Solution to Global Warming. Michael C. Brower. Union of Concerned Scientists, 1993.

Global Resources: Opposing Viewpoints Greenhaven Press, 1991.

Power Surge: Guide to the Coming Energy Revolution. Christopher Flavin and Nicholas Lenssen. W.W. Norton & Co., 1994.

Renewable Energy Sourcebook: A Primer for Action. Public Citizen, 1995.

### Pamphlets: (Scriptographic Press)

About Alternative Energy Sources
About Solar Energy
Let s Learn about Energy and the Environment
The ABC's of Electric Power from the Atom

### Websites:

http://battelle.org/pr/pr2gas.html
http://www.bynmawr.edu/Acads/Geo/Geol03/PostTripReports/Kim.html
http://classes.colgate.edu/core114/legislation/ecopain/copy/renerabl.htm
http://ecep1.usl.edu.ecep.sources/c/c.htm
http://zebu.uoregon.edu/energy.html

FUELS - NOW AND IN THE FUTURE
ANALYSIS SHEET #1
GROUP NAMES: _____

_____

_____

_____

***Group explorations***

Once your group has been assigned a particular energy source, use the pamphlets provided by your teacher, the Internet, SMRC (science & math resource center), and other sources to answer the following questions:

A. What are the general locations and sources of the energy?

B. How easy is it to procure and transport it?

C. What is the cost per unit of energy? How much per Joule? (show your work!)

D. What are the environmental concerns of your fuel? Are these concerns local and/or global in scope? Look also at production, transportation, after use contaminants, hazards to workers, possible leaks and spills, other forms of pollution. What would result if a natural disaster occurred during its procurement or during its transport?

E. Design a presentation of your findings (5 min. per group) for the class using overheads, white boards, or other form.

**HANDOUTS:** (One copy per person is suggested.)

FUELS – NOW AND IN THE FUTURE ANALYSIS SHEET #2

Sources of our energy

A. List the major sources of energy used in our location.

B. List the types of energy produced in our location.

C. Where do these eight energy sources come from?

**HANDOUTS:** (One copy per person is suggested.)

FUELS- NOW AND IN THE FUTURE ANALYSIS SHEET #3

GROUP NAMES: _____

_____

_____

_____

Debriefing

Once your new group has formed, answer the following questions:

A. Once your group has picked a number corresponding to a geographic location somewhere in the world, determine what the top two forms of energy are for that location. Again, design a presentation (3 min./group) to present your recommendations to the class. Record your supporting arguments here.

B. What changes were made to your choice of energy sources by the class? Why were the changes made? If no changes were made, briefly describe the class discussion on your location and choice of energy source.

C. What did you find out about the fuels, what does it mean, and what should we do with this knowledge?

**HANDOUTS:** (One copy per person is suggested.)

FUELS- NOW AND IN THE FUTURE ANALYSIS SHEET#4

GROUP NAMES: _____

_____

_____

_____

***Extensions***

After the class has brainstormed on future sources of energy, answer the following questions:

A. What current fuels may be used more commonly in the future? Less commonly in the future?

B. What are some new sources of energy?

C. How might these new sources affect our particular community and our entire world?

D. Individual Assignment- Pick one of the following:
   1. Write a 2-3-paragraph news article that could appear in the science section of a newspaper in the year 2015 concerning one of the new sources of fuel.
   2. Write a letter to the editor explaining why your fuel type is important to your community.

**Fuel Clue Cards:**

**Oil:**
Non-renewable
Formed in Ground
Needs to be refined
Can be broken into other components
Messy
Can be piped

**Solar:**
Plentiful
Works well in Florida, poor in Alaska
Free source of energy
At times unreliable
Equipment is costly to install and maintain
Renewable

**Geothermal:**
Heat energy from beneath the earth's crust
Magma is an example
Generally only from Western U.S.
Old Faithful
Comes in high and low temperatures
Has little pollution

**Wind:**
Above ground energy source
Caused by different temperatures
Renewable
Used heavily in Holland
Frequently by seashores and hills
At times unreliable

**Gas:**
Non-renewable
Can be used directly
Low density
Colorless
Can be piped
Heat measured in therms

**Nuclear:**
Caused by atoms splitting
Non-renewable
Produced bombs during WWII
Heat powers an electric generator
Waste removal
Fuel is concentrated from ore

**Hydro:**
Energy of moving water
Renewable
Economical
Does not itself cause pollution
Uses a turbine
Niagara Falls had first one

**Coal:**
Formed millions of years ago from the remains of animals and plants
Non-renewable
Can be mined
May cause black lung
Hard and soft forms available

---

**FUEL CLUE CARD INSTRUCTIONS:**
Based on the number of students present, divide the cards into at least four clues per fuel. You may not be able to use all fuels. Give one card to each student. They are to arrange themselves into groups according to their clue characteristics of a particular fuel. They also have to determine what fuel they are describing. Some clues are repeated, so some may have to change to another group.

---

**Sharon Dimonski** – Trinity High School, Cleveland, OH
**Kathleen Wheeler** – Trinity High School, Cleveland, OH

## OVERVIEW:

The intent of the lesson is to make students aware that human actions have global consequences. Students will graph and analyze fish collection data from Lake Erie and the oceans. They will relate their data analysis to environmental issues concerning the world's fishing industry.

## PREREQUISITES:

**SKILLS:**
- Reading table of data
- Sorting data
- Basic graphing
- Percent skills
- Basic research ability

**KNOWLEDGE:**
- Great Lakes location
- Basic knowledge of ocean location
- Basic fishing practices

## MATERIALS:

For "Deadly Waters":
- Graph paper (1 sheet per group)
- Pollution Information Sheet (1 per group)
- Glue stick (1 per group)
- Teaspoon (1 per class)
- 1000 hole-punch size circles (100 each of 10 different colors)

For "The Common Dilemma":
- 1 lb. bag M & M's
- 1 Paper Plate per group of 4

For class assignment:
- 2 Lake Erie Commercial Data Sheets ( one of each per student)
- Ocean Marine Yield Data Sheet (1 per student)

## ANTICIPATED OUTCOMES:

The student will be able to:

- select required information from data table
- construct bar/line graphs
- compare/contrast data from different years using graphs
- recognize patterns of fish catch increases/decreases
- identify possible reasons for fluctuations in fish populations
- relate human activity to fish population changes
- compare/contrast coastal ocean management with deep ocean management

## CONNECTIONS TO PROFICIENCY TEST (9th grade):

The students will read, interpret, and use tables, charts, graphs, and maps to identify patterns, note trends, and draw conclusions. They will learn: to distinguish between observation and inference; to identify and apply science safety procedures; to explain biological diversity in terms of transmission of genetic characteristics; and to describe how organisms accomplish basic life functions at various levels of organizations and structure.

## INTRODUCTION: (30 minutes for two activities)

**ACTIVITY 1:** Deadly Waters from Project Aquatic

Group students by fours. Give each group one sheet of graph paper, a glue stick, a pollution information sheet, and 1 tsp. of assorted colored hole-punch circles. Students should sort circles by colors and create a bar graph by gluing the circles in, by color, to the graph paper using labeled axes.

Students should identify types and volumes of pollutants in their specific "group river". The class should briefly discuss why each river and its pollutants is different (e.g. location, industry/agriculture/urban, etc.) Evaluate how this will affect the local collecting lake.

**ACTIVITY 2:** The Commons Dilemma (adapted from a study done by Robert Gifford of the University of Victoria)

Introduce this simulation with a discussion of the following ground rules, supplying only the information needed to get the students started. The dilemma and a discussion of the various strategies should surface at the end of the activity. Divide them into groups of 4. Give each group a paper plate (sea) and 16 M & M's (fish).

## GROUND RULES:

The object of this activity is to harvest as many fish as possible from the sea. At any one time, your sea can hold (has a carrying capacity of) a maximum of 16 fish. For every four fish each student harvests, he/she will receive one point. This is his/her "profit" as a fisherman. The more fish you harvest, the more points you will receive.

When the game begins, you may harvest all the fish, some of the fish, or none. Each student, in turn, will have 10 seconds to fish. You will be told when to start and when to stop each trial.

If fish remain after each trial, a new fish will be added for each fish remaining. If their are 2 fish left, 2 will be added. But for each new trial, the total number of fish in the sea cannot be more than the carrying capacity of 16 fish.

## TRIALS:

When all 4 trials are finished, each student should divide his/her pile of fish into fours. For every 4 fish the student will receive 1 point: = the profit.

Then have the group total up their fish, make piles of 4 and add up the points the group would receive.

**Discussion Questions:**

What were the maximum points achieved by any individual? Group?

Why were fish only replaced if some remained on the plate? (simulates natural conditions)

What happens when individual group members don't use a cooperative strategy?

What was the best strategy for harvesting from this commons? (8 each trial)

Discuss stewardship (cooperative strategies that show concern for a resource). Have students name other resources that require our stewardship. How will increased population affect this? How does this lead to marine life depletion?

## EXPLORATION: (40 minutes)

The students will graph fish catch data from Lake Erie, the Great Lakes and the World's oceans. Distribute the three data sheets , 1 to each student. Have students work in groups of 3 or 4 to produce 3 bar graphs, a line graph, and a pie graph. Students will need to determine the proper axes, scales and labels.

**BAR GRAPH #1:** Display the 1978-80 catches of the following fish: Carp, Channel Catfish, Lake Trout, Northern Pike, Salmon, Sheepshead, Walleye, White Bass, and Yellow Perch

**BAR GRAPH #2:** Display the 1988-90 catches of the same fish.

**BAR GRAPH #3:** Combine bar graphs 1 and 2 to produce a bar graph display which shows a comparison of the above fish for 1979-80 and 1988-90. The group will need to agree on a defined key for this comparison graph.

**LINE GRAPH:** Display, on one set of axes, the Ohio 1978-80 and the 1988-90 catches of the same fish that were graphed in the bar graphs. Use two different line codes. Make sure to key the line codes on your graph.

**PIE GRAPH:** Using the totals for either 1978-80 or 1988-90, compare Ohio fish yields to the other Great Lakes states and countries.

**DEBRIEFING:** (10 minutes)

Groups need to analyze their graphs to determine which types of fish increased or decreased in Ohio. They need to compare this information to the catches of the other states and Ontario that border Lake Erie for the same time span. Have the groups share their data. Then, have the students discuss possible reasons for the changes in these fish yields. What activities of humans could be responsible? What natural processes? Considering that Lake Erie is connected to the oceans by the St. Lawrence Seaway, can problems in the Lake Erie basin affect the oceans? Any global consequences?

**EXTENSIONS** ( approximately 20 minutes in class, plus homework)

Giving each student the Marine Yields and Exploitation data sheet. The students will organize the data to produce one bar graph and one line graph.

*Bar graph:* Show the three types of catches (Marine Fish, Cephalopods, Crustaceans) for the 5 main bodies of water. Code the bar for marine fish with one design, the bar for cephalopods (eel and octopus) with another design, and the crustacean bar with a third design. Make sure the bar codes are keyed on the graph. Use two different colors, one for 1981-83 and a different color for 1991-93. (Example: The Atlantic Ocean should have 6 bars representing it. Three bars are in one color, but with different designs to represent the three different catches in 1981-83. The other three bars are in a different color but the same three designs to represent the Atlantic catches in 1991-93.)

*Line graph*: Using total marine yield data, the students will create a line graph using different colors to compare the five bodies of water on graph. Make sure to indicate the key being used.

**HOMEWORK:**

Using resources given to them in class, students are to search the web for current information on overfishing in the oceans. They may also use any other resources they choose.

**NEXT CLASS:**

Students will analyze the graphs they have drawn and compare it to the information they were able to get off the web or other sources. We will discuss the reasons for fish depletion. We will compare their information to the Common Dilemma Game from the previous day. Using their data tables, the students will discuss the implications of the column titled % of stocks fully fished, overfished, depleted or recovering in 1992. What is the relationships of the Lake Erie graphs to the global graphs? This will lead into concerns for the changing ecosystem of the oceans and the affect of the human species.

**RESOURCES:**

Books:


World Resources, A Guide to the Global Environment, The Urban Environment 1996-97, Oxford University Press, New York, p. 309.

The Great Lakes, An Environment Atlas & Resource Book, United States EPA, 1995


Internet: www.dnr.ohio.gov
www.glfc.org/comdat

Video: The Great Experiment, Films for the Humanities (1996)

Great Lakes, Bitter Legacy, PBS Videos

# POLLUTANT INFORMATION SHEET

## SEDIMENT

Particles of soils, sand, silt, clay and minerals wash from land and paved areas into creeks and tributaries. In large unnatural quantities, these natural materials can be considered a pollutant. Construction projects often contribute large amounts of sediment. Certain lumbering practices affect sediments in runoff. Sediments may fill stream channels and harbors that later require dredging. Sediments suffocate fish and shellfish populations by covering fish nests and clogging the gills of bottom fish and shellfish.

## PETROLEUM PRODUCTS

Oil and other petroleum products like gasoline and kerosene can find their way into water from ships, oil drilling rigs, oil refineries, automobile service stations and streets. Oil spills kill aquatic life (fish, birds, shellfish and vegetation). Birds are unable to fly when oil loads the feathers. Shellfish and small fish are poisoned. If it is washed on the beach, the oil requires much labor to clean up. Fuel oil, gasoline and kerosene may leak into ground water through damaged underground storage tanks.

## ANIMAL WASTE

Human wastes that are not properly treated at a waste treatment plant and then released to water may contain harmful bacteria and viruses. Typhoid fever, polio, cholera, dysentery (diarrhea), hepatitis, flu and common cold germs are examples of diseases caused by bacteria and viruses in contaminated water. The main source of this problem is sewage getting into the water. People can come into contact with these microorganisms by drinking the polluted water or through swimming, fishing or eating shellfish in polluted waters. Often unexpected flooding of barnyards or stock pens can suddenly increase the toxic effects of animal waste in water. Animal wastes can also act as a fertilizer and create damage by increasing nutrients. (see Fertilizers)

## ORGANIC WASTES

Domestic sewage treatment plants, food processing plants, paper mill plants and leathering tanning factories release organic wastes that bacteria consume. If too much waste is released, the bacterial populations increase and use up the oxygen in the water. Fish die if too much oxygen is consumed by decomposing organic matter.

## PESTICIDES, HERBICIDES, FUNGICIDES

Agricultural chemicals designed to kill or limit the growth of life forms are a common form of pollution. This pollution results from attempts to limit the negative effects of undesirable species on agricultural crop production. Irrigation, groundwater flow and natural runoff brings these toxic substances to rivers, streams, lakes and oceans.

## INORGANIC CHEMICALS

Inorganic chemicals and mineral substances, solid matter and, metal salts commonly dissolve into water. They often come from mining and manufacturing industries, oil field operations, agriculture, and natural sources. These chemicals interfere with natural stream purification; they destroy fish and other aquatic life. They also corrode expensive water treatment equipment and increase the cost of boat maintenance.

## DETERGENTS AND FERTILIZERS

Many of these substances are toxic to fish and harmful to humans. They cause taste and odor problems and often cannot be treated effectively. Some are very poisonous at low concentrations. The major source of pollution from agriculture comes from surplus fertilizers in the runoff. Fertilizers contain nitrogen and phosporous that can cause large amounts of algae to grow. The large algae blooms cover the water's surface. The algae die after they have used all of the nutrients. Once dead they sink to the bottom where bacteria feed on them. The bacterial populations increase and use up most of the oxygen in the water. Once the free oxygen is gone, many aquatic animals die. This process is called eutrophication.

## HEATED OR COOLED WATER

Heat reduces the ability of water to dissolve oxygen. Electric power plants use large quantities of water in their steam turbines. The heated water is often returned to streams, lagoons, or reservoirs. With less oxygen in the water, fish and other aquatic life can be harmed. Water temperatures that are much lower than normal can also cause habitat damage. Deep dams often let extra water flow downstream. When the water comes from the bottom of the dam, it is much colder than normal.

## ACID PRECIPITATION

Aquatic animals and plants are adjusted to a rather narrow range of pH levels. pH is a measure of the acidity of a solution. When water becomes too acid, due to inorganic chemical pollution or from acid rain, fish and other organisms die.

# BACKGROUND TO LAKE ERIE

The Great Lakes play an important role in the social, political, cultural and industrial development of the communities that surround them. These bodies of water provide drinking water, transportation routes, power, recreational areas and food for millions.

Lake Erie is the smallest and shallowest of the Great Lakes. This presents a problem. Due to the lake's size, it is exposed to the greatest effects of changes. These changes, in the past, have resulted from changes in forestation, loss of wetland filters at the mouth of drainage rivers, urbanization, fertilization overloads, and seasonal temperature changes. In the early history of the settlement of the region there was no thought as to the effects of all this change on the ecosystem. Logging removed protective trees from stream banks, increased erosion. So did sawmills. Framing increased erosion of soil, runoff and debris which destroyed stream habitats. Fishing with no thought top conservation wiped out whole population of fish.

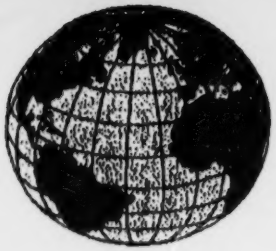
Fertilizers and phosphates from laundry detergents caused major algal bloom in Lake Erie in the 1950's, 60's and 70's. This created massive loss of oxygen from the lakes and the rivers around Lake Erie. This killed off many populations of fish and other aquatic organisms. The pollution was so bad, and fish yields so poor, that commercial fishing all but vanished and Lake Erie was declared a dead lake.

Based on information from the US EPA, commercial fishing began around 1820 with the largest catches recorded in 1889 and 1899 (147 million pounds). Preferred species declined by 1880. Techniques become more advanced and resulted in the commercial fishing industry declining for good in the 1950's. Larger fish have given way to smaller species of less value. Pockets of lake trout, sturgeon and lake herring survive in vastly reduced numbers. Overfishing combined with habitat destruction, toxic wastes and the introduction of exotic species are responsible for these changes. Canada still fishes these species but under agreements with the US to monitor catch sizes. Fish farms and restocking plans have helped some species of Lake Erie Fish to recover.

Since the 1970's many local, national and international laws have been developed to protect the Lake Erie and the rest of the Great Lakes. Even with these laws we still aren't out of danger. With the increased apathy resulting from the improvements made to the Lake Erie basin, we have once again increased fishing, both commercial and sport, and recreational uses of the lake. We are also loosening the reigns of the Clean Water act to allow industry to pollute more. We have not leaned from the past.

This lack of learning is evident on the oceans today. We are destroying the great natural fisheries. Many species have been overfished. According to the World Wildlife Fund 131 of 152 of the most harvested species are now threatened, endangered or extinct. Many techniques have been harmful - bottom dredging, netting, long-line fishing and bycatch dumping. We are also using our coastal areas as offshore dumping grounds for toxic wastes, medical wastes and human garbage. According to the Greenpeace foundation, only 31% of our oceans have been deemed as unexploited. Since these areas are mostly open ocean, no country can write laws to save it. International agreements are needed and these are difficult to achieve and enforce.

40



# Lake Erie
# Commercial Fishing Data

All data in thousands of pounds

Data for each state and Ontario

| Fish Type | MI | | NY | | OH | | PA | | ONT | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 78/80 | 88/90 | 78/80 | 88/90 | 78/80 | 88/90 | 78/80 | 88/90 | 78/80 | 88/90 |
| Buffalo | 76 | 69 | 0 | 0 | 98 | 250 | 0 | 0 | 0 | 0 |
| Burbot | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 20 | 1 | 3 |
| Carp | 1238 | 769 | 10 | 0 | 4895 | 3096 | 0 | 0 | 119 | 20 |
| Channel Catfish | 70 | 28 | 1 | 1 | 697 | 951 | 1 | 0 | 267 | 151 |
| Gizzard Chad | 0 | 0 | 2 | 0 | 4001 | 40 | 6 | 213 | 1 | 683 |
| Lake Trout | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 1 | 0 |
| Lake Whitefish | 0 | 0 | 0 | 0 | 0 | 23 | 3 | 159 | 8 | 290 |
| Northern Pike | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 94 | 18 |
| Salmon | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 43 | 0 |
| Quillback | 0 | 2 | 0 | 0 | 265 | 264 | 0 | 0 | 0 | 0 |
| Sheepshead | 2 | 1 | 44 | 0 | 3363 | 1780 | 202 | 90 | 959 | 912 |
| Smelt | 0 | 0 | 0 | 2 | 14 | 0 | 14 | 0 | 75569 | 54395 |
| Walleye | 0 | 0 | 208 | 0 | 0 | 0 | 44 | 32 | 3562 | 21087 |
| White Bass | 20 | 2 | 40 | 0 | 5153 | 1069 | 35 | 30 | 5301 | 12475 |
| Yellow Perch | 4 | 0 | 368 | 51 | 7571 | 4056 | 940 | 581 | 33466 | 31870 |
| TOTALS | 1410 | 871 | 673 | 54 | 26057 | 11529 | 1250 | 1125 | 119391 | 121904 |

SOI : Great Lakes Fishing Commission web page; www.g .g/comdat 6/24/98

# Lake Erie
# Commercial Fishing Data

## All data in thousands of pounds

| Fish Type | 1978-80 | 1988-90 |
|---|---|---|
| Bowfin | 67 | 12 |
| Buffalo | 174 | 319 |
| Bullheads | 314 | 235 |
| Burbot | 3 | 23 |
| Carp | 6262 | 3885 |
| Channel Catfish | 1036 | 1131 |
| Gizzard Chad | 4010 | 936 |
| Goldfish | 1038 | 61 |
| Lake Trout | 4 | 0 |
| Lake Whitefish | 11 | 472 |
| Northern Pike | 94 | 18 |
| Salmon | 43 | 0 |
| Quillback | 265 | 266 |
| Rock Bass | 127 | 8 |
| Sheepshead | 4570 | 2783 |
| Smelt | 75599 | 54395 |
| Suckers | 306 | 126 |
| Sunfish | 148 | 61 |
| Walleye | 3814 | 21119 |
| White Bass | 10549 | 13576 |
| White Perch | 0 | 14317 |
| Yellow Perch | 42349 | 36558 |
| TOTAL CATCH | 150783 | 150301 |

SOURCE: Great Lakes Fishing Commission web page, ww.glfc.org/comdat/erie.htm 6/24/98

42

# Marine Yields and State of Exploitation

(Source: World Resources, A Guide to the Global Environment, The Urban Environment 1996-97, Oxford University Press, New York, p.309.)

| Body of Water | Marine Catch in Metric Tons: Marine Fish 1981-83 | Marine Fish 1991-93 | Cephalopods 1981-83 | Cephalopods 1991-93 | Crustaceans 1981-83 | Crustaceans 1991-93 | (in Metric Tons) Total Marine Catch 1981-83 | Total Marine Catch 1991-93 | % of Stocks fully fished, overfished, depleted, or recovering in 1992 |
|---|---|---|---|---|---|---|---|---|---|
| **Atlantic** | 20,021,612 | 17,952,537 | 462,521 | 1,033,307 | 800,437 | 988,810 | 21,284,570 | 19,974,654 | x |
| Northwest | 1,897,887 | 1,577,845 | 51,029 | 40,365 | 202,057 | 305,189 | 2,150,973 | 1,923,399 | 67 |
| Northeast | 10,282,914 | 9,270,963 | 41,737 | 44,194 | 211,097 | 249,000 | 10,535,747 | 9,564,156 | 61 |
| Western Central | 1,488,739 | 1,290,928 | 10,179 | 20,198 | 240,278 | 265,441 | 1,739,195 | 1,576,567 | 37 |
| Eastern Central | 2,781,365 | 3,072,082 | 193,295 | 219,203 | 44,844 | 64,340 | 3,019,504 | 3,355,625 | 85 |
| Southwest | 1,227,792 | 1,385,200 | 155,899 | 701,456 | 87,039 | 90,653 | 1,470,730 | 2,177,309 | 82 |
| Southeast | 2,342,915 | 1,355,519 | 10,383 | 7,891 | 15,122 | 14,187 | 2,368,421 | 1,377,598 | x |
| **Pacific** | 32,561,167 | 42,562,810 | 1,007,483 | 1,485,455 | 1,492,360 | 2,924,635 | 35,061,010 | 46,972,900 | x |
| Northwest | 16,966,580 | 17,696,934 | 730,777 | 887,824 | 786,514 | 1,608,874 | 18,483,871 | 20,193,632 | 100 |
| Northeast | 1,787,664 | 2,429,484 | 22,751 | 19,061 | 96,162 | 209,971 | 1,906,577 | 2,658,516 | 50 |
| Western Central | 4,623,724 | 6,630,468 | 157,116 | 272,053 | 447,947 | 867,112 | 5,228,787 | 7,769,634 | 63 |
| Eastern Central | 1,461,318 | 1,192,035 | 22,712 | 47,582 | 88,678 | 80,591 | 1,572,708 | 1,320,208 | 29 |
| Southwest | 361,883 | 733,006 | 71,796 | 78,525 | 8,174 | 7,291 | 441,853 | 818,822 | 45 |
| Southeast | 7,359,998 | 13,880,883 | 2,331 | 180,410 | 64,885 | 150,796 | 7,427,214 | 14,212,089 | 50 |
| **Indian** | 3,627,006 | 5,957,119 | 32,818 | 132,166 | 405,268 | 616,398 | 4,065,091 | 6,705,683 | x |
| **Mediterranean/ Black Seas** | 1,559,733 | 1,163,870 | 50,623 | 69,885 | 34,870 | 49,628 | 1,645,227 | 1,283,383 | x |
| **Antarctic** | 148,559 | 56,923 | 0 | 0 | 401,659 | 250,137 | 550,218 | 307,060 | x |
| **Arctic** | 0 | 0 | x | x | x | x | x | x | x |



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**Linda Orange** – Lake Ridge Academy, North Ridgeville, OH
**Veronica Riffle** – Lake Ridge Academy, North Ridgeville, OH

**OVERVIEW:**

The intent of this lesson is for the student to develop a working knowledge of noise pollution. Noise, defined as unwanted sound, can cause loss of hearing or lead to anxiety, stress or fright with consequent adverse physiological effects. More than ten years ago, the EPA established the Clean Air Act, Clean Water Act, Solid Waste Law and laws controlling radiation and noise. (Goldfarb,1991). Noise can be reduced by more careful design of machinery, by installation of acoustical materials or by use of ear protection. There is an undercurrent of background noise that invades our everyday existence in our highly technical world.

**PREREQUISITES:**

SKILLS: Math: Computing with integers, fractions, decimal, graphing. Working in basic statistical analysis.
Science: Working proficiency with MBL system and data collection.

KNOWLEDGE: Math: understanding of standard and metric units of measure, evaluating algebraic expressions, manipulating. ratios and proportions, appropriate graph applications.
Science: An understanding of the terms of amplitude, frequency, pitch, constructive and destructive interference, sound levels (decibels) and intensity factors.

**MATERIALS:**

MBL Micro-computer Based Laboratory (Bank Street Laboratory) with Sound Sensor
Meter sticks, Clinometers (for height measurement)
Various acoustical materials, depending on students' experimental design
Bill Nye Video " Sound"

**ANTICIPATED STUDENT OUTCOMES:**

The students will be able:

1. To demonstrate the difference between sound and noise.
2. To identify noises in the environment.
3. To design and conduct two experiments
    a. On the intensity of the noise at various distances.
    b. The effect of different acoustical environments on noise.
4. To analyze the quantitative results of their experiments.

**CONNECTIONS TO THE PROFICIENCY TEST:**

1. Computations with appropriate metric units of measure.
2. Convert, compare and compute with common units of measure within the same measurement system.
3. Read the scale on a measurement device to the nearest mark and make interpolations where appropriate.
4. Read, interpret and use tables, charts and graphs to identify patterns, note trends and draw conclusions.
5. Apply concepts of sound and light waves to everyday situations.
6. Be able to distinguish between observation and inference given a representation of a scientific situation.
7. Draw conclusions and/or recognize a conceptual model based on a given set of data.
8. Make inferences about the causes of variation in experimental results.
9. Compare renewable and non-renewable resources and strategies for managing them.
10. Relate the effect on an ecosystem to a given environmental change.

**INTRODUCTION:**

1. Hearing/Listening Activity:
   *NOTE: You may want to do this activity outside, weather permitting.)*
    a. Students are to have a paper and pencil in front of them.
    b. Tell students when you say say "Begin", they are to sit for 3 minutes in absolute silence. At the end of the 3 minutes, they are to write a list of everything they heard..
2. Round robin in small groups to develop a composite list.
3. Compile group lists on the board.
4. Show the class Bill Nye's music video on sound.
5. General discussion about what constitutes pleasant sound v. unpleasant sound.
6. In same small groups students will separate class data into two categories: noise and sound. Have student recorder draw a T-chart with two columns. Title one column "SOUND" and the other column "NOISE."

**DEBRIEFING:**

Based on small group findings, conduct a general discussion on each group's impressions of:

1. What sounds do we consciously hear?
2. What sounds do we subconsciously absorb?
3. What sounds are pleasant?
4. What sounds are intrusive?

Bring class to general consensus on a working definitions of Sound and Noise.

**EXPLORATION:**

1. In the same small groups the students choose a "noise" from the class-generated list.
2. Each group will then design two experiments to measure the intensity (in decibels) of the noise using the MBL and the sound sensor. Have students in each group include a written job description for each group member. *(See Handout)*
3. The variables in the experiment are to be:

    a. Changing the unobstructed distance from noise source to the sound sensor to answer the questions: "What is the relationship between intensity of sound and distance?" and then:
    b. At a fixed distance, inserting different materials to obstruct the sound waves from the noise source to the sound sensor to answer the question: "What materials are better suited for reducing or eliminating the noise?
4. Students will get approval of their experimental design by conferencing with teacher. In the conference, have students identify the following items in their experimental design:
    a. constants and variables
    b. number of trials
    c. methods of measurement.
5. Student groups will conduct their experiments and collect their data.
6. Each group will graph the data from the first experiment using a line graph.
7. Label coordinates; "Distance v Decibels".
8. Each group will graph the fixed distance data on a bar graph.
8. The group will draw conclusions based upon their data to answer the following question:
    a. "What are the optimum conditions for reducing the noise level to approximately 40 decibels?"
9. Each group will present their findings to the entire class.

**EXTENSION:**

1. Students will choose and research a "real-life" community situation where one has to make accommodations for the environmental noise.
2. Based on their research, each will develop a position on the issue.
3. The students will debate their position in a classroom simulation.

**RESOURCES:**

*Books:*

Anthrop, Donald E. Noise Pollution. San Francisco

Goldfarb, Theodore. Taking Sides: Clashing Views on Controversial Environmental Issues. Guilford, Conn.:The Dushkin Publishing Group, Inc., 1991.

Taylor, Rupert. Noise. New York, Penguin Books, 1970

*Teacher Resource Workbooks:*

Strengthening of Skills Program developed by Research for Better Schools, 444 North Third Street, Philadelphia, PA 19123

Experiments in Physical Science The Bank Street College Project in Science and Mathematics. Sunburst Communications, 101 Castleton Street, Pleasantville, New York 10580

*Video:*

Bill Nye the Science Guy. "Sound" KCTS-TV, PBS Seattle.

*Internet:* http://www.nonoise.org/aboutno.htm Noise Pollution Clearinghouse http://europa.eu.int/en/record/green/gp9611/noiseum.htm Green Paper on noise policy.

EXPERIMENT: ARE YOU LISTENING?

NAME:_____

PROBLEM:

Now that you have distinguished between noise and sound, the question is how do we best eliminate or at least minimize noise in our environment? Your group has chosen one of the noises from our class-generated list. You and your group will design two separate but related experiments.

PROCEDURE:

1. Design two experiments to measure the intensity (in decibels) of the noise using the sound sensor.
Design one experiment to answer the first question and the next experiment to answer the second question:
    1. What is the relationship between the intensity of a noise and its distance from you?
    2. What materials are better suited for reducing and/or eliminating noise?

2. Divide the labor in your group. Each person is to write his/her own job description .
3. Make an appointment with me to go over your procedure. In the conference, I will be looking for the following items in your experimental design: materials, constants and variables, number of trials, methods of measurement.
4. Once your procedure has been approved, begin collecting your materials and conduct your first experiment.
Remember, everyone has a job to do! I will be looking to see that each person in your group is fulfilling their role. ALL DATA ARE TO BE LOGGED IN YOUR LAB NOTEBOOK.
5. After your group has collected data on for the first experiment, make a decision on which distance is the optimum distance to conduct the second experiment.
6. Collect your materials for your second experiment and begin.
7. After sufficient data has been collected:
    -Graph the data from the first experiment using a line graph.
    Label coordinates: "Distance v. Decibels"
    -Graph the fixed distance data from the second experiment on a bar graph.
8. Your group will draw conclusions based on their data to answer the following question:
    "What are the optimum conditions for reducing the noise level to approximately 40 decibels?"
9. Be prepared to present your findings to the entire class. Each member of your group is to participate in the presentation. Create visuals with your evidence to support your findings.

**Table 18–2**
**Sound Levels and Human Responses**

| Sound Intensity Factor | Sound Level, dB | Sound Sources | Effects: Perceived Loudness | Effects: Damage to Hearing | Effects: Comm React Outdc Noise |
|---|---|---|---|---|---|
| 1,000,000,000,000,000,000 | 180 | Rocket engine | | | |
| 100,000,000,000,000,000 | 170 | | | | |
| 10,000,000,000,000,000 | 160 | | | Traumatic injury | |
| 1,000,000,000,000,000 | 150 | Jet plane at takeoff | Painful | | |
| 100,000,000,000,000 | 140 | | | Injurious range: irreversible damage | |
| 10,000,000,000,000 | 130 | Maximum recorded rock music | | | |
| 1,000,000,000,000 | 120 | Thunderclap | | | |
| 100,000,000,000 | 110 | Textile loom<br>Auto horn, 1 m away<br>Riveter | Uncomfortably loud | | |
| 10,000,000,000 | 100 | Jet fly-over at 300 m<br>Newspaper press | | Danger zone: progressive loss of hearing | |
| 1,000,000,000 | 90 | Motorcycle, 8 m away<br>Food blender | Very loud | | Vigor act |
| 100,000,000 | 80 | Diesel truck, 80 km/hr, 15 m away<br>Garbage disposal | | Damage begins after long exposure | Threa |
| 10,000,000 | 70 | Vacuum cleaner | | | |
| 1,000,000 | 60 | Ordinary conversation<br>Air conditioning unit, 6 m away | Moderately loud | | Wides com |
| 100,000 | 50 | Light traffic noise, 30 m away | | | Occas com |

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49

**Table 18–2** *(Continued)*
**Sound Levels and Human Responses**

| Sound Intensity Factor | Sound Level, dB | Sound Sources | Effects: Perceived Loudness | Effects: Damage to Hearing | Effects: Community Reaction to Outdoor Noise |
|---|---|---|---|---|---|
| | | Average living room | | | |
| 10,000 | 40 | Bedroom | Quiet | | No action |
| | | Library | | | |
| 1000 | 30 | Soft whisper | | | |
| 100 | 20 | Broadcasting studio | Very quiet | | |
| 10 | 10 | Rustling leaf | | | |
| | | | Barely audible | | |
| 1 | 0 | Threshold of hearing | | | |

disturbances. The emotional effects on people are difficult to measure, but psychologists have learned that work efficiency goes down as the noise level goes up.

There are three techniques that can be used to control noise.

**1. Reduce the Source** Machinery should be designed so that parts do not needlessly hit or rub against each other. It is possible to design machines that work quietly. For example, rotary saws can be used to break up street pavement. They do the job perfectly well and are much quieter than jackhammers. Another approach is to change operating procedures. If a suburban sidewalk must be broken up by jackhammers, it would be better not to start early in the morning, when many people are asleep. Also, aircraft take-offs can be routed over less densely inhabited areas. All too often, machines are built to perform a task most efficiently without consideration of how much noise is produced. If machines were originally designed properly, noise levels could be substantially reduced.

**2. Interrupt the Path of Transmission** Sound waves travel through air. They also travel through other media, including solids such as wood. However, some materials, especially soft or porous ones, absorb sound. Such sound-absorbing media are called **acoustical materials.** Acoustical tiles and wallboard can be used in house construction to reduce noise levels. The muffler used in automobile exhaust systems is another example of a sound-absorbing device.

**3. Protect the Receiver** The final line of defense is strictly personal. We protect ourselves instinctively when we hold our hands over our ears. Alternatively, we can use ear plugs or earmuffs, as shown in Figure 18–8. (Stuffing in a bit of cotton does very little good.) A combination of ear plugs and earmuffs can reduce noise by 40 or 50 dB, which could make a jet plane sound no louder than a vacuum cleaner. Such protection could prevent the deafness caused by combat training (Fig. 18–9) and should also be worn for recreational shooting.

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The Bank Street Laboratory

# Experiment Book

TEACHER'S EDITION

Experiments
in physical
science

The Bank Street College Project in Science and Mathematics

51

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## PURPOSE

In this Lab you will determine why one sound is considered a musical note while another is considered noise.

## PROCEDURE

## MATERIALS

BSL
BSL microphone
Microphone stand
Computer printer (optional)
Trace sheets

*You may want to start this Lab by inviting you students to engage in a debate about the difference between music and noise. (This is a pertinent question for many adolescents and their parents.) Although the distinction is made in the Lab based on the presence or absence of repetition in the wave form, there is much room for discussion about the role of dissonance in music, about what a "pleasant" sound is, etc. You can return to this discussion at the end of the Lab.*

## BEFORE YOU START

Samuel Johnson once wrote. "Of all noises I think music the less disagreeable." What do you think is the difference between music and noise?

## EXPERIMENT: WHAT MAKES A SOUND MUSICAL?

A. Start the Bank Street Laboratory software, connect the microphone, and set the microphone on a stand.

B. Select Sound from the Main Menu, Scope from the Sound Menu and Two Waves from the Scope Menu. Select Far from the screen.

C. Begin measuring on the upper display. Hum a note with your lips held together. Make the hum louder or softer until the trace just fills the display. Once you have a good trace, freeze the display. Sketch and label the wave.

D. Activate the lower display. Now make a hissing sound, "ZZZ" or "SSS". Hold the microphone far enough from your mouth so that the hiss is not too loud. Make sure that that the trace doesn't quite fill the trace box. If the trace is too large you will lose some information. Freeze the hiss on the lower display and compare it with your trace of the hum.

Which of the two traces has a clearly repetitive pattern?
*The humming sound has a repetitive, periodic pattern, The pattern produced by the hissing sound does not.*

E. Use this twin trace technique to compare various sounds, both musical and noisy, and to test your hypothesis. Draw the traces for each of the sounds and label them on your trace sheet. Compare sounds and describe the similarities and differences about the traces.
*A musical note is produced by regular vibrations that show a repetitive trace on the BSL waveform display. A noise is produced by irregular vibrations that show no such repetition. Students can test this hypothesis by obtaining traces of known notes and noises.*

52

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*Some students may have been to a dentist who uses music or "white noise" to block the sound of the drill. White noise is used in other contexts as well to mask unpleasant or distracting noises. For example, in cities people often block out the sounds of the street with a fan or other mechanical device (or with music).*

*Trace examples are available at the back of the Teacher's Edition. You may want to duplicate them to share with your students.*

F. Try a range of various sounds and place them in the following table which has been started for you. Separate the steady, regular musical notes from the irregular, "messy looking" noises.

| Notes | Noises |
|---|---|
| Person humming<br>Car horn | Person hissing<br>Car engine |

1. Where in your table do you think a computer printer would fit? Test it to find out if you prediction is correct.

*A noise.*

## PURPOSE

In this Lab you will study the harmonic structure of complex sounds.

## MATERIALS

BSL

BSL loudspeaker and microphone

Microphone stand

Harmonic display sheets

## PROCEDURE

*Students should be reminded that the fundamental (lowest frequency) of a tone determines the pitch one perceives. The higher frequencies of the harmonics in the tone determine the timbre of the sound.*

## BEFORE YOU START

Recall the waveform trace you made of the sound of a tuning fork. The simple waveform of such pure tones has a special name: a sinusoidal wave. If you have had trigonometry in math class you will recognize this waveform as a graph of a sine or cosine function. For this reason, the sinusoidal wave is often called a "sine wave." Sinusoidal waves are very important for the scientific study of sound because by adding together more and more sinusoidal waves with different frequencies you can produce any repetitive waveform you like, including the complex ones you have studied so far.

When a complex waveform is analyzed into its component frequencies, the lowest frequency is called the fundamental and the higher frequencies are called harmonics.

## EXPERIMENT: THE HARMONIC STRUCTURES OF MUSICAL NOTES AND NOISE

A. Start the Bank Street Laboratory software and connect the microphone. Set the microphone on the stand.

B. Select Sound from the Main Menu. Select Frequency from the Sound Menu. Click on Bar and select Far from the screen. Select Start when you are ready to begin.

By doing rapid and sophisticated calculations, BSL can recognize the separate frequencies that are present in a sound. The screen shows a frequency scale on which the BSL displays a line on the frequency scale for each harmonic frequency it detects. The length of each line corresponds to the relative loudness of the corresponding frequency in the full sound.

C. Hum quietly near the microphone. Try to hum so that the display shows only a single line. It helps to hum a note that is easy for your voice. If nothing at all appears on the display you will have to hum louder or move closer to the microphone. If more than one line appears, try humming less loudly. When you are successful, freeze the display on the screen. Now try humming a high note and then a low note.

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Why does the line on the display move up and down?

*The height of the line depends on frequency.*

D. Next, sing the vowel "o." Once you have a good display, freeze it on the screen. Sketch the harmonic structure on one of your harmonic display sheets and label it. Explore the harmonic structures of different vowel sounds such as "ah" and "ee."

E. When you have finished working with musical notes, follow the same procedure with other kinds of sounds. As before, make sketches of your results and label them. Try blowing gently into the microphone for one kind of sound, and making a hissing sound ("sss") for another.

Compare your sketches for musical notes with those for noisy sounds. What do the harmonic structures of musical notes have in common? How do they differ from the harmonic structures of unmusical noises?

*Musical notes are made up of only a few harmonics. Noise produces relatively many harmonics with unrelated frequencies.*

*A synthesizer can construct musical tones by adding together simple sinusoidal waves of different frequencies. By approximating the proper harmonic structure and waveform, notes from different musical instruments can be produced.*

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## PURPOSE

In this Lab you will study sound prints.

## MATERIALS

BSL
BSL loudspeaker and microphone
Microphone stand

## PROCEDURE

*Biologists use sound prints to study animal communication. Students could examine sound prints from recordings of bird songs or of sounds made by whales and porpoises.*

## BEFORE YOU START

So far we have studied primarily steady sounds, both musical and noisy. Many naturally occurring sounds are much more variable. Their loudness, frequency, and harmonic structure may change rapidly over time. The BSL can work with changing sounds as well as steady ones. The way it does this is to divide the changing sound into very short sections and then find the harmonic structure of each section. The result is called a sound print.

One of the most remarkable of all natural sounds is the sound of human speech. Consider the many kinds of information that our speech conveys. Not only do we use words, but we express feelings and intentions through variation in the quality of our speech. The BSL also can make sound prints of speech. These are called voice prints.

## EXPERIMENT: SOUND PRINT OF A WHISTLE

A. Start the Bank Street Laboratory software and connect the microphone. Set the microphone on the stand.

B. Select Sound from the Main Menu. Select Frequency from the Experiments Menu. Select Sound Print from the Frequency Menu. Select Start when you are ready to begin.

The display will show two plots. The top one is just like the graph of Magnify and shows variation in loudness. After the data have been collected, BSL will move the cursor across the display in steps. The frequencies present in each section are displayed in the lower plot. You can stop the analysis at any time.

C. Begin the analysis and whistle a varying pitch like a siren. It is important to get the volume right so that the upper plot is roughly half-filled with sound. If the sound is too quiet, BSL will have nothing to analyze and you get no results. If the sound is too loud, BSL will distort it and the results will not be reliable. You can also adjust the sensitivity of the microphone with the Far/Near setting.

D. Once the display looks good, study the two traces and think about what they reflect. Select Print from the File Menu to obtain a hard copy of the sound print. The upper trace shows variation in loudness.



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The lower trace shows variations in the fundamental and harmonics. Listen while BSL plays back the sound from its analysis. Does it sound like the original? As BSL plays back the sound, study the sound print. you should try to understand the display well enough to explain it to someone else.

## EXPERIMENT: VOICE PRINTS

PROCEDURE

A. Repeat the sound print of a whistle experiment but instead of whistling, speak a word such as "laboratory." As before, you will need to practice to get the volume just right. Get voice prints of several of your classmates saying the same words. If you can, print out hard copies for later study. You can also play back the speech to help understand the plots. Next, try saying the same phrase, such as "thanks a lot," with different emotional tones, such as angry, bored, sincere, sarcastic. Also, compare a questioning tone with an imperative one.

B. Consider the voice prints you have seen and examine them if you have hard copies. Do you think voice prints may be as good a way to identify people as fingerprints?

*Responses will vary but should include the observation that people have markedly different voice prints of the same word.*

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NPC Noise Pollution Clearinghouse

# About Noise, Noise Pollution, and the Clearinghouse

Noise is unwanted sound; it is derived from the Latin word "nausea," meaning seasickness. Noise is among the most pervasive pollutants today. Noise from road traffic, jet planes, jet skis, garbage trucks, construction equipment, manufacturing processes, lawn mowers, leaf blowers, and boom boxes, to name a few, are among the unwanted sounds that are routinely broadcast into the air.

The problem with noise is not only that it is unwanted, but also that it negatively affects human health and well-being. Problems related to noise include hearing loss, stress, high blood pressure, sleep loss, distraction and lost productivity, and a general reduction in the quality of life and opportunities for tranquillity.

We experience noise in a number of ways. On some occasions, we can be both the cause and the victim of noise, such as when we are operating noisy appliances or equipment. There are also instances when we experience noise generated by others just as people experience second-hand smoke. While in both instances, noises are equally damaging, second-hand noise is more troubling because it has negative impacts on us but is put into the environment by others, without our consent.

The air into which second-hand noise is emitted and on which it travels is a "commons," a public good. It belongs to no one person or group, but to everyone. People, businesses, and organizations, therefore, do not have unlimited rights to broadcast noise as they please, as if the effects of noise were limited only to their private property. On the contrary, they have an obligation to use the commons in ways that are compatible with or do not detract from other uses.

People, businesses, and organizations that disregard the obligation to not interfere with others' use and enjoyment of the commons by producing noise pollution are, in many ways, acting like a bully in a school yard. Although perhaps unknowingly, they nevertheless disregard the rights of others and claim for themselves rights that are not theirs.

We have organized to raise awareness of noise pollution and help communities take back the commons from those acting like bullies. Our efforts include building a library of resources and tools concerning noise pollution, establishing links to other groups that have similar collections, establishing networks among local noise activists, assisting communities and activists who are working to reduce noise pollution, and monitoring and advocating for stronger noise controls.

**Home Top**

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58

# NPC Noise Pollution Clearinghouse

**The NPC Index to Noise in the News**

Noise News is an important feature of the NPC Online Library. It contains summaries and excerpts of relevant noise related articles appearing in newspapers and other periodicals. Noise News is updated weekly. To see a list of our latest updates, see What's New.

Search the NPC Noise News Database

**Features of the Month:**
Important New Study of Nighttime Noise Effects
Important Study of Effects of Aircraft Noise on Children

Noise News is sorted by:

| | Date (Chronologically) | Geographical Area | |
|---|---|---|---|
| Aircraft Noise | Amplified Noise | Civil Liberty Issues | Construction Noise |
| Effects on Wildlife/Animals | Environmental Justice | Firing Ranges | Health and Well-Being Issues |
| Home Equipment and Appliances | Industrial/Manufacturing Noise | International News | Land Use and Noise |
| Lawsuits | Miscellaneous | Noise in our National Parks | Noise Ordinances |
| Noise Organizations | Outdoor Events | Regulation | Research and Studies |
| Residential and Community Noise | Snowmobile and ATV Noise | Technological Solutions to Noise | Transportation Related Noise |
| Violence and Noise | Watercraft Noise | Workplace Noise | |

Noise News is brought to you as a joint effort between the Noise Pollution Clearinghouse and the Institute for Local Self-Reliance (ILSR). The ILSR is a nonprofit research and educational organization that assists us in gathering current news stories from around the world.

59

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**NPC Library Home**

Some newspapers have databases that you can search for noise stories. If you are interested in a story that is more than one year old, you might try one of these:

The Christian Science Monitor

# Green Paper on future noise policy

## EXECUTIVE SUMMARY


- Introduction
- The Noise Situation in the European Union
- Analysis of Existing Noise Abatement Actions in the European Union
- A New Framework for Noise Policy
- Conclusion


Environmental noise, caused by traffic, industrial and recreational activities is one of the main local environmental problems in Europe and the source of an increasing number of complaints from the public. Generally however action to reduce environmental noise has had a lower priority than that taken to address other environmental problems such as air and water pollution.

The 1993 Fifth Environmental Action Programme started to remedy this and included a number of basic targets for noise exposure to be reached by the year 2000, while the recent proposal on the review of the Fifth Action Programme (COM(95)647) announces the development of a noise abatement programme for action to meet these targets.

This Green Paper is the first step in the development of such a programme and aims to stimulate public discussion on the future approach to noise policy. It reviews the overall noise situation and Community and national action taken to date followed by the outline of a framework for action covering the improvement of information and its comparability and future options for the reduction of noise from different sources.

### The Noise Situation in the European Union

The data available on noise exposure is generally poor in comparison to that collected to measure other environmental problems and often difficult to compare due to the different measurement and assessment methods. However it has been estimated that around 20 percent of the Union's population or close on 80 million people suffer from noise levels that scientists and health experts consider to be unacceptable, where most people become annoyed, where sleep is disturbed and where adverse health effects are to be feared. An additional 170 million citizens are living in so-called 'grey areas' where the noise levels are such to cause serious annoyance during the daytime.

A wide variety of studies have examined the question of the external costs of noise to society especially transport noise. The estimates range from 0.2% to 2% of GDP. The Commission's Green Paper 'Fair and Efficient Pricing in Transport' used the lower estimate of 0.2% of GDP which represents an annual cost to society of over 12 billion ECU.

### Analysis of Existing Noise Abatement Actions in the European Union

For more than twenty years Community environmental noise policy has essentially consisted of legislation fixing maximum sound levels for vehicles, aeroplanes and machines with a single market aim, or to implement international agreements in the case of aircraft, linked to certification procedures to ensure that new vehicles and equipment are, at the time of manufacture complying with the noise

limits laid down in directives.

Thanks to this legislation and technological progress significant reductions of noise from individual sources have been achieved. For example the noise from individual cars has been reduced by 85% since 1970 and the noise from lorries by 90%. Likewise for aircraft the noise footprint around an airport made by a modern jet has been reduced by a factor of 9 compared to an aircraft with 1970s technology.

However data covering the past 15 years do not show significant improvements in exposure to environmental noise especially road traffic noise. The growth and spread of traffic in spaceand time and the development of leisure activities and tourism have partly offset the technological improvements. Forecast road and air traffic growth and the expansion of high speed rail risk exacerbating the noise problem. In the case of motor vehicles other factors are also important such as the dominance of tyre noise above quite low speeds (50 km/h) and the absence of regular noise inspection and maintenance procedures.

For some sources such as railways and a wide range of noisy equipment used outdoors there are no Community or international standards setting emission limits. A number of Member States are planning national legislation for these products, which could cause problems for the functioning of the single market.

Most Member States have adopted legislation or recommendations setting immission limits for noise exposure in sensitive areas. These are often integrated into national abatement laws and used in land use plans especially for new infrastructure developments. A survey done for the Commission has shown a considerable degree of convergence between Member States in the establishment of such quality criteria for road, rail and industrial noise. The situation for aircraft noise indices and exposure levels is more divergent.

**A New Framework for Noise Policy**

In the light of the poor state of data on noise exposure and the shortcomings identified in the analysis of existing policy measures, the Commission believes that changes in the overall approach are required if a noise abatement policy is to be successful. This requires a framework based on shared responsibility involving target setting, monitoring of progress and measures to improve the accuracy and standardisation of data to help improve the coherency of different actions.

The local nature of noise problems does not mean that all action is best taken at local level, as for example generally the sources of environmental noise are not of local origin. However effective action is very dependent on strong local and national policies and these need to be more closely related to the measures to be decided at Community level. In this context there is scope for cooperation across the Community to improve the data situation and the comparability of information and in addition the Community could assist in the exchange of experience in noise abatement between Member States. The main area for Community involvement will remain linked to the reduction of noise from products. Here the Commission will be looking to broaden the range of instruments applied and paying particular attention to the potential of economic instruments, whose use to date is not widespread in noise abatement.

The proposed new framework outlines options for future action :

1. A proposal for a directive providing for the harmonization of *methods of assessment of noise*

62

*exposure* and the mutual exchange of information. The proposal could include recommendations on noise mapping and the provision of information on noise exposure to the public. In a second stage consideration could be given to the establishment of target values and the obligation to take action to reach the targets.

2. The next phase of action to reduce *road traffic noise* will address tyre noise and look at the possibilities of integrating noise costs into fiscal instruments, amending Community legislation on road-worthiness tests to include noise and at the promotion of low noise surfaces through Community funding.

3. More attention needs to be paid to *rail noise* where some Member States are planning national legislation and where there is considerable opposition to the expansion of rail capacity due to excessive noise. In addition to supporting research in this field the Commission will investigate the feasibility of introducing legislation setting emission limit values, negotiated agreements with the rail industry on targets for emission values and economic instruments such as a variable track charge.

4. In *air transport* the Commission is also looking at a combination of instruments. These would include greater stringency in emission values and the use of economic instruments to encourage the development and use of lower noise aircraft, as well the contribution local measures such as land use planning could make. A specific framework directive on airport charges is planned for 1996. A consultation paper on stringency in emission values is to be presented in the near future.

5. The Commission plans to simplify the existing legislation setting emission limits for a limited range of *outdoor equipment* and will propose a framework directive covering a wider range of equipment including construction machinery, garden equipment and others and incorporate the existing seven directives. The principal feature of the new legislation will be the requirement to label all equipment with the guaranteed noise level. Limit values will only be proposed for equipment for which there is already noise legislation and a limited range of highly noisy equipment.

**Conclusion**

One of the main aims of this paper is to help to give noise abatement a higher priority in policy making. It is focusing on the areas where Community action in cooperation with Member States and local authorities can be of added value. The options for action on measurement methods and exchange of information cover important steps for the establishment of an overall framework for action. More work is required to assess the best combination of instruments to be applied to the different modes of transport.

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[EUROPA] ["On the Record"] [Green Papers]

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# Countdown to Population Explosion

Grade 6-8

**Jane Raggets** – Urban Community School, Cleveland, OH
**Sister Patricia Gentile** – Metro Catholic Parish School, Cleveland, OH

**OVERVIEW**: In this lesson, students will learn about changes in population and use of land and resources. They will see how an increase in population affects the availability of renewable and non-renewable resources. They will explore the concept of "the magnitude of millions and billions" through hands-on activities.

**PREREQUISITE**:

SKILLS - use of metric measurements - estimate - work cooperatively
KNOWLEDGE - renewable and non-renewable resources - food web

**MATERIALS**:

Introduction - 1 piece of yarn, approximately 1 foot long per student

Activity 1 - Chalk, bell, stopwatch

Activity 3 - Tape or book (The Lorax, by Dr. Seuss)

**ANTICIPATED STUDENT OUTCOMES**:

Gain awareness of changes and growth occurring locally and globally in world population from 1550-present.

Explore impact of population growth on renewable and non-renewable resources.

**CONNECTIONS TO PROFICIENCY TESTS**:

MATH - Convert, compare and compute with common units of measure within the same measurement system.
SCIENCE - Identify interrelationships of organisms within an ecosystem. Relate the effect on an ecosystem to a given environmental change.

**INTRODUCTION**: (30 minutes)

Give each student 1 piece of yarn and stand in a circle. Each student holds the yarn in their right hand. They must reach across the circle and grab another end of yarn with their left hand. This will create a tangled web. Working cooperatively, they must untangle the knot.

DISCUSS WITH STUDENTS: What happened?
So what? (Analysis) Now what? (Transfer and application)

This experience of working cooperatively will be extended to solving a larger problem with the five questions below:

1. How has your neighborhood changed in the past 5 years?
2. How has your metropolitan city changed?
3. What effect does this have on the land, resources, spread of disease?
4. How is world population changing?
5. How might this effect the land, resources, spread of disease, etc.?

**EXPLORATION**: ( 90 minutes)

**Activity 1** - "Pop Grows the Planet" - students simulate the history of world population growth; see Activity #12 from Wasserman and Sculland, Counting on People, Elementary Population and Environmental Activities, Zero Population Growth, 1994.

**Activity 2** - Students take notes on background information.

Population Facts

A population is a group of living things that are the same.

Ultimately, continued population growth would lead to a population too large for world resources.

Food production would obviously have to continue to increase in order to feed larger world populations.

In India, it is reported that rats eat stored up grain and are, in turn, eaten by snakes. The food chain stops there, however, because in India, snakes are rarely eaten by humans.

The world could not grow enough food for the entire population to eat an average American diet.

One side effect of the effort to grow more food is degradation of the environment.

Soil erosion and air and water pollution are all products of increased agricultural yield.

Ultimately, continued population growth would lead to a population too large for world resources.

from "Population" by John R. Weeks

| Country | Population | Total Area (sq. miles) |
|---|---|---|
| United States | 246,100,000 | 3,623,420 |
| Canada | 26,100,000 | 3,851,790 |
| United Kingdom | 57,100,000 | 94,525 |
| Australia | 16,500,000 | 2,967,894 |
| France | 55,900,000 | 211,207 |
| Spain | 39,000,000 | 194,896 |

**Activity 3** - Lessons from The Lorax; explore inderdependence of rapid development in an environment; see Activity 28, Counting on People.

**DEBRIEFING** ( 20 minutes) Class discussion - How does The Lorax relate to what is happening in our neighborhood, city, country, world? (Students discuss in small groups and report back to whole group)

**EXTENSIONS**

1. Students write an editorial to their newspaper regarding concerns relating to the problems of population explosion. (30-40 minutes)
2. Activity - Millions and Billions (Math connection); see attached sheet
3. Use Population chart from Activity 2 and have students figure population density. Also, students can look up and compare countries on a map to see relative sizes.
(Math/Soc. St. connection)

**RESOURCES:**

Weeks, John R. Population. (1994) Watsworth, Inc. Belmont, CA
Counting on People: Elementary Population and Environmental Activities. Zero Population Growth, 1994.

# POP GROWS THE PLANET

# ACTIVITY 12

## POPULATION CIRCLE

**Materials:**

Chalk
Bell or gong
Stopwatch or watch with a second hand

**Procedure:**

1. Draw a chalk circle on the floor about six feet in diameter. Yarn or tape may also be used to mark off the circle.
2. Ask two students to stand in the circle to represent the world's population in the year 1550, and have more students enter the circle according to the table below. (Note: If you don't want to wait 3 minutes and 20 seconds for the first interval, you could begin the simulation in the year 1750 with three people in the circle.)
3. Each student represents 250 million people (approximately the U.S. population in 1990). Each second represents one year. If there are more than 20 students, make each student represent fewer people. For example, if one student equals 100 million people, you would need about 50 students.
4. One person should be responsible for informing the group about the passage of years, the world population in numbers and the intervals in years. Be dramatic! Use a bell or gong for each new time span.

| Year | World Population (in millions) | Total in Circle (1=250 million) | Interval To Next Date | Add Participants at end of this simulation interval | Add to Circle |
|---|---|---|---|---|---|
| 1550 | 500 | 2 | 200 yrs | 3 mins., 20 secs. | 1 |
| 1750 | 750 | 3 | 60 | 1 min. | 1 |
| 1810 | 1.000 | 4 | 80 | 1 min., 20 secs. | 2 |
| 1886 | 1.500 | 6 | 41 | 41 secs. | 2 |
| 1927 | 2.000 | 8 | 22 | 22 secs. | 2 |
| 1950 | 2.500 | 10 | 10 | 10 secs. | 2 |
| 1960 | 3.000 | 12 | 15 | 15 secs. | 4 |
| 1975 | 4.000 | 16 | 12 | 12 secs. | 4 |
| 1987 | 5.000 | 20 | 12 | 12 secs. | 4 |
| 1999* | 6.000 | 24 | | | |

*projected

**Follow-up Activity:**

Put the following questions on the chalkboard: "Can the Earth's population go on doubling forever?" List students' reasons on the board. You may want to prompt them by asking them to think about food supply, clean water, homes, forests, wildlife and competition for resources.

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from Counting on People prepared by P. Wasserman and A. Scullard. Zero Population Growth, 1990

# LESSONS FROM THE LORAX

**Concept:** Economic demands can lead to excessive use of natural resources, and population growth can add to environmental stress.

**Objective:** Students analyze the interdependencies demonstrated in a fictional story of rapid development in a formerly undisturbed environment.

**Grade Level:** Lower and upper elementary

**Subjects:** Science, social studies, language arts

**Skills:** Reading comprehension, story analysis

**Introduction:** *The Lorax* by Dr. Seuss (Random House, ©1971), is the story of a beautiful woodland's destruction as economic demands lead to excessive use of its natural resources and rapid population growth adds to the environmental stress. You can use this story to introduce students to a variety of concepts related to population growth in a most entertaining way.

## ACTIVITY 28

### LESSONS FROM THE LORAX

**Materials:**

*The Lorax* by Dr. Seuss (book or video). The video version of *The Lorax* is available for rent at many video stores. It can be purchased from **ecol-o-kids**, 3146 SW Shadow Lane, Topeka, KS 66604; (913) 232-4747 for $13.95 plus $3.00 shipping and handling. *The Lorax* book is available in the children's section of most major bookstores and libraries.

**Procedure:**

First, read *The Lorax* to your class or show them the animated, musical video. Then discuss the following questions related to the story with your students:

1. Why did the Once-ler make so many thneeds?
2. How were the animals and birds affected when the truffula trees were cut down?
3. Why did so many more Once-lers move to the area?
4. How did the rapid population growth affect the environment?
5. Think about the imaginary land in *The Lorax*, as it was before the Once-ler arrived. Did it remind you of any real place you have seen? Now think about how it looked after the population explosion changed the environment. Did it remind you of any real place you have seen?
6. What could the Once-ler have done that would have allowed him to make thneeds but not harm the environment so much?
7. What could the other Once-lers who moved there have done to keep it a nice place to live?

**Follow-up Activity:**

If your students enjoy *The Lorax*, recommend that they read *The Wump World* by Bill Peet (Houghton Mifflin Co., ©1970). The Wumps lead a peaceful existence in the grassy meadows of Wump World until the Pollutians from Pollutus land on their world and begin changing their environment. This is a classic appropriate for all ages.

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from Counting on People prepared by F. Wasserman and A. Scotland, Zero Population Growth 1994

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# MILLIONS AND BILLIONS

## ACTIVITY 5

### MEASURING A MILLION

**Materials:**

2 reams of paper (1,000 sheets)
Meter sticks (one for each group of four students)
Student Worksheets (1 per student)

**Procedure:**

Divide the class into groups of three or four. Have a representative from each group come to the front of the room and count out 100 sheets of paper for their group, and to collect a meter stick. Distribute the Student Worksheets which ask the students to complete the following assignments:

**How tall would a million sheets of paper be? How about a billion sheets of paper?**

Note: Answers may vary depending on the type of paper measured. A stack of 100 sheets of photocopy paper is approximately 1.3 cm high, so a stack of one million sheets is approximately 130 meters high and a stack of one billion sheets is approximately 130,000 meters (or 130 km) high.

**Discussion Questions:**

1. Can you think of anything that is about the same height as a million sheets of paper? How about a billion sheets of paper?

   *A million sheets of copy paper would be about 130 meters high, or the height of a tall building over 40 stories. A billion sheets of paper would be over 72 miles high!*

2. There are nearly six billion people on Earth. Is this a little or a lot? How does this compare with the 260 million people living in the United States?

   *The world population is 23 times the size of the U.S. population. The United States is the third most populated country in the world.*

4. If you lived in a city with a million people, what might there also be a million of?

   *Answers might include houses, cars, televisions, chairs, tables, etc.*



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# MILLIONS AND BILLIONS

## STUDENT WORKSHEET

NAME_____ DATE_____

Problem: How tall would a million sheets of paper be? How tall would a billion sheets of paper be?

**Process:**

1. I would estimate that the height of a stack of a million sheets of paper would be _____ centimeters.

2. The average estimate for my group is _____ centimeters.

3. The height of 100 sheets of paper is _____ mm or _____ centimeters.

4. Based on the information in #3, the height of 1,000,000 sheets of paper is _____ mm or _____ cm or _____ meters. Remember: 1,000,000 = 100 x 10,000.

5. Based on the information in #4, the height of 1,000,000,000 sheets of paper is_____ meters.



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# ACTIVITY 12

## POPULATION CIRCLE

**Materials:**

Chalk
Bell or gong
Stopwatch or watch with a second hand

**Procedure:**

1. Draw a chalk circle on the floor about six feet in diameter. Yarn or tape may also be used to mark off the circle.
2. Ask two students to stand in the circle to represent the world's population in the year 1550, and have more students enter the circle according to the table below. (Note: If you don't want to wait 3 minutes and 20 seconds for the first interval, you could begin the simulation in the year 1750 with three people in the circle.)
3. Each student represents 250 million people (approximately the U.S. population in 1990). Each second represents one year. If there are more than 20 students, make each student represent fewer people. For example, if one student equals 100 million people, you would need about 50 students.
4. One person should be responsible for informing the group about the passage of years, the world population in numbers and the intervals in years. Be dramatic! Use a bell or gong for each new time span.

| Year | World Population (in millions) | Total in Circle (1=250 million) | Interval To Next Date | Add Participants at end of this simulation interval | Add to Circle |
|---|---|---|---|---|---|
| 1550 | 500 | 2 | 200 yrs | 3 mins., 20 secs. | 1 |
| 1750 | 750 | 3 | 60 | 1 min. | 1 |
| 1810 | 1,000 | 4 | 80 | 1 min., 20 secs. | 2 |
| 1886 | 1,500 | 6 | 41 | 41 secs. | 2 |
| 1927 | 2,000 | 8 | 22 | 22 secs. | 2 |
| 1950 | 2,500 | 10 | 10 | 10 secs. | 2 |
| 1960 | 3,000 | 12 | 15 | 15 secs. | 4 |
| 1975 | 4,000 | 16 | 12 | 12 secs. | 4 |
| 1987 | 5,000 | 20 | 12 | 12 secs. | 4 |
| 1999* | 6,000 | 24 | | | |

*projected

**Follow-up Activity:**

Put the following questions on the chalkboard: "Can the Earth's population go on doubling forever?" List students' reasons on the board. You may want to prompt them by asking them to think about food supply, clean water, homes, forests, wildlife and competition for resources.

71

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# LESSONS FROM THE LORAX

**Concept:** Economic demands can lead to excessive use of natural resources, and population growth can add to environmental stress.

**Objective:** Students analyze the interdependencies demonstrated in a fictional story of rapid development in a formerly undisturbed environment.

**Grade Level:** Lower and upper elementary

**Subjects:** Science, social studies, language arts

**Skills:** Reading comprehension, story analysis

**Introduction:** *The Lorax* by Dr. Seuss (Random House, ©1971), is the story of a beautiful woodland's destruction as economic demands lead to excessive use of its natural resources and rapid population growth adds to the environmental stress. You can use this story to introduce students to a variety of concepts related to population growth in a most entertaining way.

## ACTIVITY 28

### LESSONS FROM THE LORAX

**Materials:**

*The Lorax* by Dr. Seuss (book or video). The video version of *The Lorax* is available for rent at many video stores. It can be purchased from **ecol-o-kids**, 3146 SW Shadow Lane, Topeka, KS 66604; (913) 232-4747 for $13.95 plus $3.00 shipping and handling. *The Lorax* book is available in the children's section of most major bookstores and libraries.

**Procedure:**

First, read *The Lorax* to your class or show them the animated, musical video. Then discuss the following questions related to the story with your students:

1. Why did the Once-ler make so many thneeds?
2. How were the animals and birds affected when the truffula trees were cut down?
3. Why did so many more Once-lers move to the area?
4. How did the rapid population growth affect the environment?
5. Think about the imaginary land in *The Lorax*, as it was before the Once-ler arrived. Did it remind you of any real place you have seen? Now think about how it looked after the population explosion changed the environment. Did it remind you of any real place you have seen?
6. What could the Once-ler have done that would have allowed him to make thneeds but not harm the environment so much?
7. What could the other Once-lers who moved there have done to keep it a nice place to live?

**Follow-up Activity:**

If your students enjoy *The Lorax*, recommend that they read *The Wump World* by Bill Peet (Houghton Mifflin Co., ©1970). The Wumps lead a peaceful existence in the grassy meadows of Wump World until the Pollutians from Pollutus land on their world and begin changing their environment. This is a classic appropriate for all ages.

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# MILLIONS AND BILLIONS

## ACTIVITY 5

### MEASURING A MILLION

**Materials:**

2 reams of paper (1,000 sheets)
Meter sticks (one for each group of four students)
Student Worksheets (1 per student)

**Procedure:**

Divide the class into groups of three or four. Have a representative from each group come to the front of the room and count out 100 sheets of paper for their group, and to collect a meter stick. Distribute the Student Worksheets which ask the students to complete the following assignments:

**How tall would a million sheets of paper be? How about a billion sheets of paper?**

Note: Answers may vary depending on the type of paper measured. A stack of 100 sheets of photocopy paper is approximately 1.3 cm high, so a stack of one million sheets is approximately 130 meters high and a stack of one billion sheets is approximately 130,000 meters (or 130 km) high.

**Discussion Questions:**

1. Can you think of anything that is about the same height as a million sheets of paper? How about a billion sheets of paper?

   *A million sheets of copy paper would be about 130 meters high, or the height of a tall building over 40 stories. A billion sheets of paper would be over 72 miles high!*

2. There are nearly six billion people on Earth. Is this a little or a lot? How does this compare with the 260 million people living in the United States?

   *The world population is 23 times the size of the U.S. population. The United States is the third most populated country in the world.*

4. If you lived in a city with a million people, what might there also be a million of?

   *Answers might include houses, cars, televisions, chairs, tables, etc.*



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# MILLIONS AND BILLIONS

## STUDENT WORKSHEET

NAME_____ DATE_____

Problem: How tall would a million sheets of paper be? How tall would a billion sheets of paper be?

**Process:**

1. I would estimate that the height of a stack of a million sheets of paper would be _____ centimeters.

2. The average estimate for my group is _____ centimeters.

3. The height of 100 sheets of paper is _____ mm or _____ centimeters.

4. Based on the information in #3, the height of 1,000,000 sheets of paper is _____ mm or _____ cm or _____ meters. Remember: 1,000,000 = 100 x 10,000.

5. Based on the information in #4, the height of 1,000,000,000 sheets of paper is_____ meters.



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## Investigating a Meadow (City Kid/Country Kid)

Grades 6-7

**Debbie Schmidt,** Margaret Splice Middle School, Cleveland, OH
**Donna Fraelich**, Western Reserve Middle School, Collins, OH

OVERVIEW-
A critical step towards improving wildlife habitat on your schoolyard site is to understand the needs of the animals you want to attract. If students keep these needs in mind as they develop a plan they will have an excellent chance for success. They will be able to collect, record, and share differences and and/or similarities of urban and rural habitats. Prior to this lesson students will have written letters to students in the partner school to begin a yearlong project.

**PREREQUISITE:**

Skills: Observation, keeping a journal, and letter writing
Knowledge: Understanding of habitats, pen pals, urban, and rural areas.

**MATERIALS:**

Whole class: hand lens, journals, pen or pencil, video tape and camera, reference books (insect, animal, plant)

Per Group: pitfall trap (cup, soap, water), hand lens

**ANTICIPATED STUDENT OUTCOME:** Students will be able to analyze a habitat. They will be able to use reference materials to identify species of plants and animals discovered in the habitat. Students will be able to record data in a journal. They will develop a sense of ownership of their habitat and develop a plan to improve the site. They will compare and contrast their site with sites at other schools in Ohio and nationally during the school year.

**CONNECTION TO PROFICIENCY TEST:**

Organize data, identify patterns and trends.
Draw conclusions and/or recognize a conceptual model based on given set of data.
Identify interrelationships of organisms within an ecosystem.

**INTRODUCTION:** (15 MINUTES) –

Film: "Outside Your Door", TV Series - Up Close and Natural 1982, WVIZ Videotape Library

Group Discussion: What did students expect to find in their "meadow"? Teacher will record comments on the board for use during the debriefing exercise.

**GOALS:**

1. Awareness and enjoyment of nature. Relationship of nature to beauty, literature, art and personal joy.
2. Awareness of concept of diversity. Application of concept to changes in nature, everything is connected, and wide range of diversity in wildlife and plants.
3. Understanding of concept that people are a part of the natural world.

**EXPLORATION:** (40 minutes)

1. Students will go to the "meadow" habitat.
2. Students will play the game, "Oh Deer" *Ohio Sampler: Outdoor and Environmental Education* Schoolyard: Activity 12
3. Students will begin their observations on the sheets given to them by the teacher. These sheets will be placed in their journals upon return to the classroom. They will be observing the plant varieties and animals or evidence of animals present in their habitat.

What do you think you will find in the meadow? Draw or write.
Why do you think the above will be in the meadow?
What did you find in the meadow? Draw or write.
What can we do to improve our meadow? Draw or write.
On the back of the paper design your idea of a "perfect" meadow.
Label what is in your meadow.

The teacher will videotape the habitat and the students working for class record and to allow the class to use the film for refresher later in the year and to share with the partner school. Students will have a visual record of the progress for possible new students or students that were absent on an outdoor activity.

These activities will enable students to select appropriate materials to enhance their "meadow" to attract and support desired species. This is a real-life learning experience and will develop a feeling of ownership of the area and an understanding of their role in the natural world.

**DEBRIEFING:**

Group will discuss their findings and compare them to their expectations expressed during the introduction. (Refer to the board)

Group will discuss their ideas of how to enhance the meadow to attract the desired wildlife.

**EXTENSIONS:** (80 minutes)

Film: Monarch Butterfly: Milkweed to Mexico- World of Nature TV Series 1991
WVIZ Video Library

Create a butterfly and write a letter for the project Monarchs to Mexico.
Install "pitfall traps" around school yard to collect insects and other organisms.
Design a butterfly and hummingbird garden.

**RESOURCES:**

Books: Carson, Rachel, *Silent Spring,* Houghton Mifflin, Boston, 1962.
Dennis, John V., *How to Attract Hummingbirds and Butterfly,* Solaris Group, San Ramon, CA, 1991.
Holt Science Textbook
Leahy, Christopher, *Peterson First Guide to Insects,* Houghton Mifflin, New York, 1978.
Project WILD K-12 Activity Guide, Western Regional Environmental Education Council, 1992.
Sedenko, Jerry. *The Butterfly Garden,* Villard Books, New York, 1991.
Van Allsburg, Chris, *Just a Dream,* Houghton Mifflin, Boston, 1990.

**RESOURCES con't.**

Internet search words:
- Monarchs to Mexico
- Globe
- Ecology/Environment

Video: Outside Your Door (Up Close and Natural)

**BACKGROUND INFORMATION:**

- Contact Monarch to Mexico coordinator
- Student contact partner school
- Teacher preview all materials

**HANDOUTS:**

- Habitat assessment sheet
- Insect Chart (4)

# INVESTIGATE A MEADOW

**NAME**_____ **DATE**_____

**Circe one:** City Country

What do you think you will find in the meadow? Draw or write

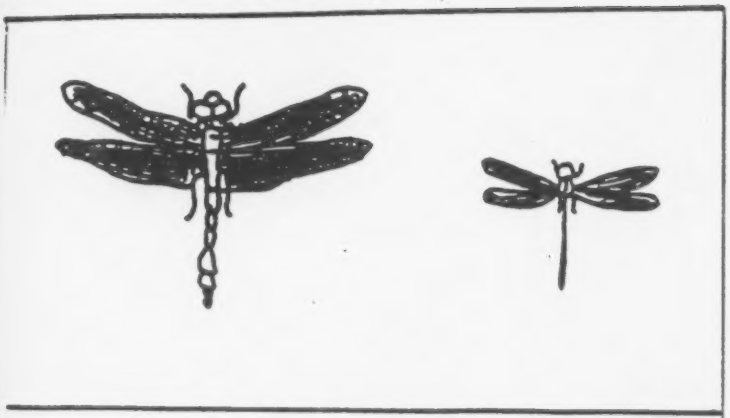
Why do you think the above will be in the meadow?

What did you find in the meadow? Draw or write

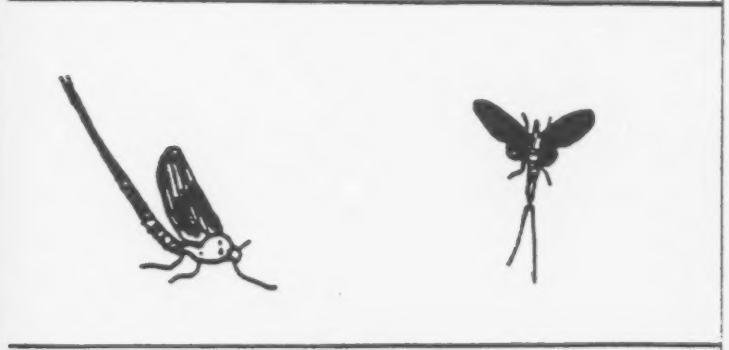
What can we do to improve our meadow? Draw or write

On the back of the paper desigin your idea of a "perfect" meadow. Label what is in your meadow.

# Insects

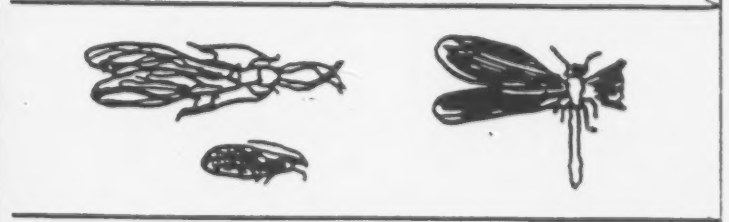


Dragonflies and Damselflies



Mayflies

Stoneflies



Dobsonflies, Lacewings, and Antlions

Flies

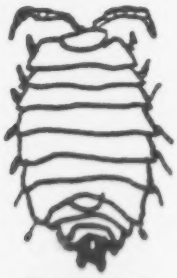
Wasps, Ants, and Bees

Adapted from Christopher Leahy, 1978, Peterson First Guide to Insects: Houghton Mifflin, New York, 128 p.

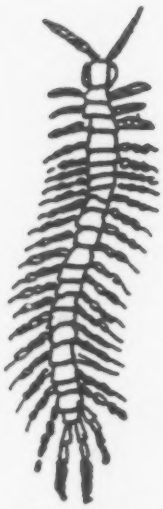
80

## Not Insects

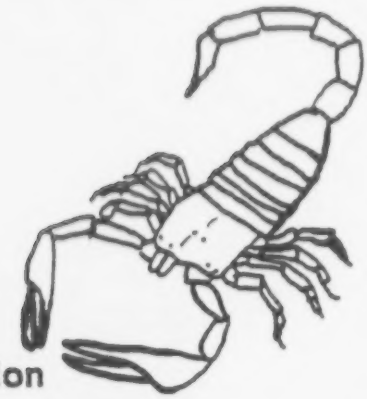
Millipede



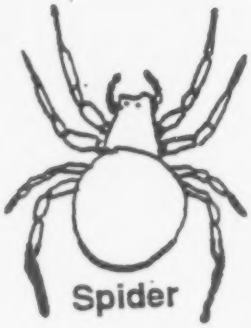
Sowbug



Centiped

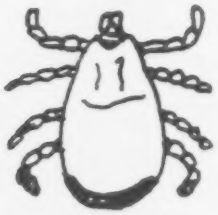


Scorpion

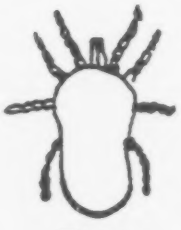


Spider

Daddy-Long-Legs



Mite

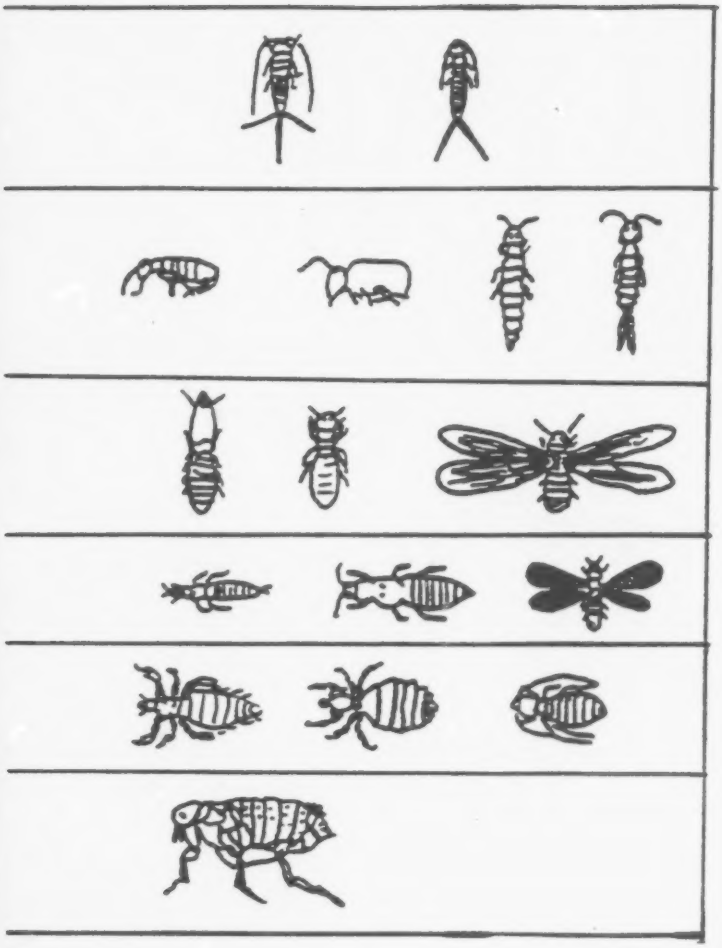


Tick

Adapted from Christopher Leahy, 1978, Peterson First Guide to Insects: Houghton Mifflin, New York, 128 p.

81

# Insects



Bristletails

Springtails

Termites

Thirps

Lice

Fleas

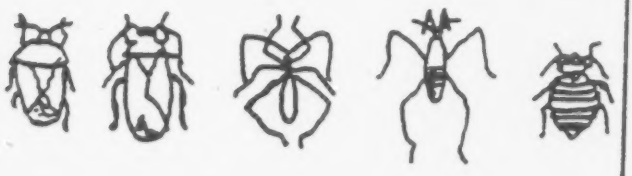
Adapted from Christopher Leahy, 1978, Peterson First Guide to Insects: Houghton Mifflin, New York, 128 p.

# Insects

Caddisflies

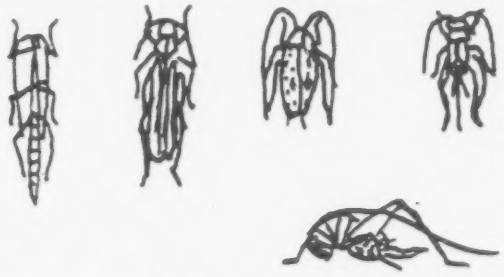
Butterflies and Moths

Beetles



Bugs

Cicadas, Hoppers, Aphids and Scale Insects



Grasshoppers, Crickets, Mantids, Walkingsticks, and Cockroaches

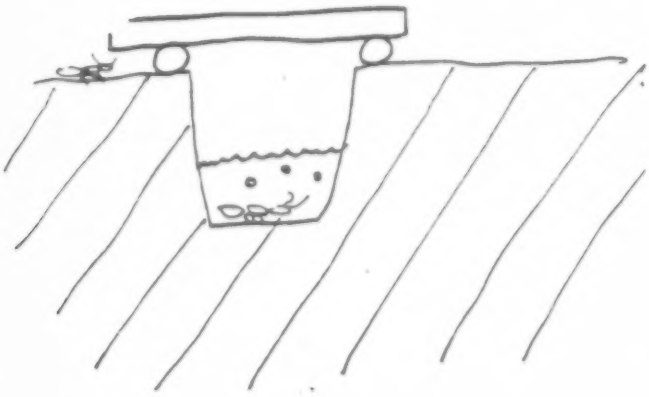
Earwigs

Adapted from Christopher Leahy, 1978, Peterson First Guide to Insects: Houghton Mifflin, New York, 128 p.

**PITFALL TRAP**

**Materials:** Plastic soft-drink cups for each student, liquid soap, water.

**Procedure:**
A "Bug" trap is illustrated below. Install these traps around school and ask students to install them near where they live. Traps should be inspected and replaced every few days. Students keep a log of number and kinds of insects and other organisms trapped. Students discuss reasons for changes in numbers and kinds of insects caught.



**MEADOW ANIMAL LIFE**

**Materials:** Pictures of meadow animals, (rabbit, cricket, grasshopper, field sparrow, fox, mouse, redwinged blackbird, meadowlark, praying mantis, butterfly, garter snake)

**Procedure:**
1. Brainstorm which animals live in the meadow. Teacher records student replies.

2. Student discussion of animals seen in meadow. Why were so few large birds and mammals seen on field trip? (Too many people, wrong time of day, too short of visit, few animals per unit area.)

3. Student discussion of indirect evidence of animals. (Burrows, nesting areas, tracks, foraging areas, droppings, skeletons, fur, feathers.)

# Send a Monarch to Mexico

**by Don Davis, Toronto, CANADA**

**Fall 1996**

This fall, the first annual "symbolic monarch butterfly migration" will be launched in collaboration with Mexico City's Museo del Nino (Children's Museum) and museums and schools across North America. You're invited to join the celebration as students across the United States and Canada create thousands of paper butterflies which will "migrate" to Mexico for the winter.

The fall flight will be timed to correspond with the real monarchs' journey south. The paper butterflies will arrive in Mexico around the time of the Dia de los Muertos (November 1), just as the real monarchs do. According to Mexican legend, these returning butterflies are thought to carry the ancestors' souls and play a role in the Dia de los Muertos celebrations. Mexican students at the Museo del Nino will greet the butterflies and watch over them during the winter months.

At the same time in the mountains nearby, the entire eastern population of North American monarch butterflies will rest in Mexico for the winter. Sometime next March, when the real monarchs' departure from Mexico is announced, the paper butterflies will return to North America. Each butterfly will carry a special message from the Mexican students to the students in Canada and U. S. who made them.

The migration of the monarch butterfly is one of the most spectacular natural phenomena in the world. It is also considered an "endangered phenomena" because scientists fear this incredible journey may not last beyond the next decade. This celebration will symbolize an international partnership between Canada, the United States, nd Mexico. Joined by a fragile butterfly, shared hope will be carried across borders and between generations.

## HOW TO MAKE YOUR MONARCH

Let your imagination go wild as you design your own monarch. Or feel free to follow one of the designs found on Journey North's WWW site at: http://www.learner.org/k12 (If you do not have access to the WWW, send a self-addressed envelope with $ .53 postage to: Journey North, 125 North First Street, Minneapolis, MN 55401) With the help of your school's art teacher, explore how your butterflies might be designed and decorated. What materials could you use to convey the fragile nature of a butterfly? What materials are needed to make sure your monarch survives its journey south, the winter months in Mexico, and its journey north next spring?

All Butterflies Must Include:

1. A message of conservation and friendship for a Mexican student, so your butterfly can serve as an ambassador of goodwill.
2. Your name and address.
3. Space for a return message from a Mexican student.

Suggestions:

- Please print CLEARLY, or print your message on a computer, so it's easy to read.
- You may want to include these things in your message: The distance your butterfly will travel to Mexico City (in km and miles), your e-mail address, your latitude and longitude.
- For extra writing space, make a tiny envelope and glue it under the butterfly's wing. Insert a letter

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inside.
- "Tag" your butterfly the way a real monarch is tagged (A self-adhesive label would work well).
- If possible, write your message in Spanish.

## HOW TO SEND YOUR MONARCH TO MEXICO

Remember, migration is a risky business. Please follow these instructions very carefully so your butterflies survive their migration!!

- Butterflies should be received by October 20, 1996.
- Mail your butterflies in a large manila envelope to: Journey North, 125 North First Street , Minneapolis, Minnesota 55401 USA
- On the front of the envelope, indicate the number of butterflies enclosed.
- MOST IMPORTANTLY! You must enclose a large, self-addressed, stamped manila envelope for your butterflies' return trip. The postage must be sufficient to mail the butterflies back to you from the Journey North office in the U.S. (The monarchs will not be mailed from Mexico, so either U. S. or Canadian postage is fine.)

## More About Your Butterfly's Journey

The Journey North office will become a migration staging area for paper butterflies this fall. In late October, the butterflies will be packaged into large boxes and carried to Mexico. They will be on display all winter at the Papalote. Museo del Nino, where hundreds of children will see them every day. When the real monarchs leave Mexico in the spring, our friends at Papalote will return the butterflies to the Journey North office. There they will be put into the envelopes which you and other classrooms provided for their return trip. Sometime next spring, your envelope will arrive and inside you'll find the same number of butterflies you sent to Mexico--but they won't be your own. These new butterflies will tell you their stories, as you discover who made them and where they have travelled.

## PREPARING FOR THE JOURNEY SOUTH

As you prepare to send your monarch to Mexico, the following resources and activities may be helpful.

**Resources**

- Tape C-NBC News on Saturday, OCTOBER 5 at 5:30 pm (Eastern Daylight Time) The Journey North program will be featured, including beautiful footage of the monarch sanctuaries in Mexico.
- The discovery of the monarch wintering sanctuaries in Mexico was announced by Dr. Fred Urquhart exactly 20 years ago in the August, 1976 issue of National Geographic. Dr. and Mrs. Urqhuart tagged the first monarchs 59 years ago--and graciously agreed to tag the first paper monarchs for this symbolic migration!
- The August, 1996 issue of National Geographic is devoted entirely to Mexico and the EarthAlmanac page in the back provides a photo and update on the monarch sanctuaries.
- Explore Journey North's 1996 Monarch Migration section on the WWW at: http://www.learner.org/k12 Plan to track the monarchs' migration with Journey North next spring. The program begins on February 2, 1997 with news from the monarch wintering sanctuaries.

**Activities**

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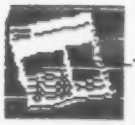
- How Far Will Your Monarch Travel? Measure the distance between your home town and Mexico City. How many miles/km will your butterfly travel? What places will your butterfly cross on its way to Mexico? What does the monarch need along the route? Write a short story about your butterfly's journey south, from a monarch's perspective.
- When Do Monarchs Leave Your Area? Keep a record of monarch sightings by students in your classroom this fall. When was the last monarch seen? Each week, take a walk outside and look for flowers. Keep track of the date you see the last goldenrod or other wild asters in bloom. When does the first frost occur? What happens to the flowers? How does the date of first frost compare to the date the last monarch butterfly was seen?
- Where Do the Monarchs Go? All migratory monarchs east of the Rocky Mountains spend the winter in just 9 major sanctuaries in Mexico! See the map of these sanctuaries on the Journey North WWW site at: http://www.ties.k12. mn.us/~jnorth/graphics/monarchmap1.gif Look carefully and see if you can form a theory about the monarchs' winter habitat. Why do you suppose monarchs go to these sites? What seems to be unique about them?

## This Project is Conducted in Partnership With:

- Papalote, Museo del Nino (Children's Museum of Mexico City)
- The Canadian Museum of Nature
- The Association of Science and Technology Centers (ASTC)
- The Science Museum of Minnesota
- The Annenberg/Corporation for Public Broadcasting Math & Science Project
- The National Fish and Wildlife Foundation



... Butterfly WebSite Article Index

*Last Updated: Last Updated: Sept 17, 1997* butterfly@mgfx.com

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# Oh, Deer!

*Objective:* Students will be able to: (1) identify and describe food, water, and shelter as three essential components of habitat; (2) describe the importance of good habitat for animals; (3) define "limiting factors" and give examples; and (4) recognize that some fluctuations in wildlife populations are natural as ecological systems undergo a constant change.

*Materials needed:*

Chalkboard or flip chart
Writing materials

*Setting:* Indoors or outdoors, in an area large enough for students to run

*Subject area(s):* Science, math, social studies, physical education

*Grade levels:* Elem.4–Senior High

*Group size:* Small group, class, or 2-3 classes

*Procedures:*

- Begin by telling students that they are about to participate in an activity that emphasizes the most essential things that animals need in order to survive. Review the essential components of habitat with the students: food, water, shelter, and space in a suitable arrangement.
- Mark two parallel lines on the floor or ground, 10–20 yards apart. Divide the students into four groups. One group stands behind one of the lines; the other three groups stand behind the other line.
- The small group becomes the "deer." All deer need good habitat in order to survive. For the purposes of the activity, we will assume that the deer have enough space in which to live. We are emphasizing food, water, and shelter. When a deer is looking for food, it should clamp its hands over its stomach. When it is looking for water, it puts its hands over its mouth. When it is looking for shelter, it holds its hands together over its head. A deer can choose to look for any one of its needs during each round of the activity; the deer cannot, however, change what it is looking for during that round. It can change again what it is looking for in the next round, if it survives.
- The other students become food, water, and shelter—components of habitat. Each student gets to choose at the beginning of each round which component he/she will be during that round. The students depict which component they are in the same way the deer show what they are looking for; that is, hands on stomach for food, etc.
- The game begins with all players lined up on their respective lines (deer on one

side, habitat components on the other side)—and with their backs to the students at the other line.

- The facilitator begins the first round by asking all the students to make their signs—each deer choosing what it is looking for, each habitat component deciding what it is.
- When you can see that all the students are ready, count: "one...two...three." At the count of three, each deer and each habitat component turn to face the opposite group, continuing to hold their signs clearly.
- When the deer see the habitat component they need, they run to it. Each deer must hold the sign of what it is looking for until it gets to a habitat component with the same sign. The first deer to reach each correctly matching habitat component takes the habitat component back to the deer side of the line. This is to represent the deer's successfully meeting its needs, and successfully reproducing as a result. Any deer that fails to find what it was looking for dies and becomes part of the habitat. That is, in the next round, the deer that died is a habitat component, and so is available as food, water, or shelter to the deer that are still alive. If no deer needs a particular habitat component during a round, the habitat component just stays where it is in the habitat. The habitat person can, however, change which component it is from round to round.
- You as the facilitator keep track of how many deer there are at the beginning of the game and at the end of each round. Continue the game for approximately 15 rounds, then gather the students together to discuss the activity. Encourage them to talk about what they experienced and saw.
- Using the chalkboard or flip chart, post and line-graph the data. (Each round is a year.) The students will see a visual reminder of what they experienced during the game—the deer population fluctuated over a period of years. Wildlife populations do tend to peak, decline, and rebuild; peak, decline, and rebuild—as long as there is good habitat and a sufficient number of animals to successfully reproduce.
- In discussion, ask the students to summarize some of the things they have learned from this activity. What do animals need to survive? What are some of the "limiting factors" that affect their survival? Are wildlife populations static, or do they tend to fluctuate? Why? Is nature ever really in "balance," or are ecological systems involved in a process of constant change?

*Submitter:* Neel Summers

I have been a teacher and director in the Southeast Local School's sixth-grade resident outdoor education program for many years. I have also used the "Oh, Deer!" activity with younger students in ecology classes in Wayne County Schools Enrichment Academy and with Girl Scout groups. I have found that this activity teaches an important ecological concept in a simple activity-oriented session which students greatly enjoy as they learn.

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Sheri L. Zakarowsky, Richmond Heights High School
***Grade Level Range*** Chemistry, Physical Science 9-12

## OVERVIEW:

The intent of the lesson is for the student to realize that chemicals surround them. Another is to realize the hazardous nature of substances they encounter on a daily basis. Finally, they will be able to describe the danger involved to themselves, the water supply, and the community when certain household chemicals are not disposed of properly.

## PREREQUISITE:

***Skills*** -classification, locating data, reading labels
***Knowledge*** - location of chemical products in their home, distinction between product name and contents.

## MATERIALS:

***Whole class:***
Lab handouts
Sample bottles of household chemicals with labels intact
Butcher paper
4 boxes of assorted color markers

***Per group of 3-4 students:***
1 lab handout per student
1 pre-lab homework assignment per student
1 sample bottle of a household chemical
1 sheet, 3 ft. long butcher paper
Assorted color markers

## ANTICIPATED STUDENT OUTCOMES:

The intent of the lesson is for the student to realize that chemicals surround them. Another is to realize the hazardous nature of substances they encounter on a daily basis. Finally, they will be able to describe the danger involved to themselves, the water supply, and the community when certain household chemicals are not disposed of properly.

## CONNECTIONS TO PROFICIENCY TEST:

Organize data, identify patterns & trends.
Identify and apply science safety procedures.
Analyze the effects of changing a component of a chemical system.
Predict the effect on an ecosystem due to a given environmental change.

**INTRODUCTION:** 10 minutes

Student homework assignment:

Review checklist of possible hazardous products in the home. Explain how to record required information on the homework assignment.

Discuss where to look for chemicals in their homes.

**EXPLORATION** Two 45-50 minute class periods.

Students will read the definitions of terms related to hazardous chemicals and each person in the group will summarize the definition of one of the terms for the others in the group. Next, the group will combine individual lists to develop a group list of hazardous chemicals in the home. They will look at the classifications and decide whether or not each chemical's dangers have been correctly identified. Each group will be assigned a category of chemicals based on type. One person from each group will obtain data from the other groups in order to total the number of containers of each of the products found in student homes. On a large sheet of butcher paper, each group will graphically display the number of containers of each of the products found in student homes. Groups will study Household Hazardous Waste Chart and key their chemicals accordingly.

**Second day**: 20-30 minutes

Students will read the article from the Environmental Hotline "Household Hazardous Wastes" Students will be assigned sections to describe to the others in the group. Each group will list the danger involved to themselves, the water supply, and the community when certain household chemicals are not disposed of properly. Next they will review the page "Use Safer Substitutes" and each member of the group will record one substitute they would be willing to try.

**DEBRIEFING:** 20 minutes

One student from each group will review a term describing hazardous waste. A second student will describe the graph and summarize the amount of hazardous waste of the assigned type owned by each the class members' household. A member will discuss environmental effects of chemicals. Students should then each identify the substitute product he or she plans to try at home.

**EXTENSIONS:** - one class period

Students search the internet or use the library to determine the amounts of hazardous wastes collected by communities in the U.S. each year and compare it to estimates of how much enters the ecosystems of the country because it is not collected and handled properly.

Students compare costs of products and their environmentally preferred substitutes. Estimate the savings to members of the class over the course of the year.

## RESOURCES:

***Books*** *A School- Based Waste Minimization and Education Program Administrator's Manual*, The Institute for Environmental Education 3200 Chagrin Blvd. Cleveland, Ohio 1991

*Environmental Resource Guide Nonpoint Source Pollution Prevention*, Air & Waste Management Association Education Council, One Gateway Center, Pittsburgh, PA 1995 p. 109-112

*Investigating Solid Waste Issues*, Ohio Department of Natural Resources, 2nd Edition , 1994 p.B-81 - E 92

*Waste: A Hidden Resource*, Keep America Beautiful, Inc. 2nd Edition, Mill River Plaza, 9 West Broad Street, Stamford, CT 1993

***Articles***

Schwartz, Ann, "Poisons in Your Home: A Disposal Dilemma," *Audubon*, May 1987 pp. 12-16

Toteff, Sally and Zehner, Cheri, "Toward Hazardless Waste", Seattle-King County Health Department, Seattle, WA 1985

***Internet***

Envirofacts Warehouse www.epa.gov/enviro/index_java.html
The Green Workout www.epa.gov/grtlakes/seahome/housewaste/quiz
What is Household Hazardous Waste?
www.1800cleanup.org/frames/pages/hhwaste
Environmental Defense Fund www.edf.org

## BACKGROUND INFORMATION:

Many hazardous chemicals are a part of our everyday lives, although people don't intentionally seek out products that are toxic. Some people know that many products they use are poisonous, corrosive, flammable or otherwise hazardous, but they accept the risks, believing the benefits outweigh them. The intent of this activity is to help students become aware of the meanings on warning labels so that they can make informed choices about selection of household chemicals. It is not known what percent of U.S. households use toxic chemicals, but estimates based on surveys conducted in the Seattle area place the percentage close to 98%. A desirable outcome is that students will read labels of products used in their homes not only for directions for use, but also for hazards and for appropriate disposal methods.

**HANDOUTS:** (following pages)

1. Introductory Hazardous Chemicals Home Survey - Homework
2. Terms and Categories (ISWI)
3. Household Hazardous Waste Chart (ERG)
4. Reading "Household Hazardous Waste" – check Internet sites
5. Chart "Use Safer Substitutes" (ERG)

## Terms and Categories

**C = Corrosive** Materials which cause visible destruction of, or irreversible changes in living tissue. Includes strong acids and bases.

**E= Explosive** Materials which cause sudden, instantaneous release of heat and pressure.

**F= Flammable** Materials which pose a fire hazard during routine handling. Includes alcohols and hydrocarbons.

**I= Irritant** Materials (not corrosive) which cause reversible irritating effects in living tissue. Includes mild acids and bases.

**T= Toxic** Materials which are poisonous. Care should be taken during routine handling. Includes heavy metals and other poisonous substances.

## Product Groups

List products belonging to the following groups on a sheet of notebook paper and indicate the type of hazard by marking each with **C,E, F, I,** and/or **T**.

DECORATING
AUTOMOTIVE SUPPLIES
GARDEN SUPPLIES
PETS AND HOBBIES
CLEANERS
COSMETICS
LAUNDRY SUPPLIES
BATTERIES
MISCELLANEOUS

## Introductory Hazardous Chemicals Home Survey

Look for household chemicals in your home. Use the suggestions below and add your own. List the exact product name and any warnings printed on the can. List disposal methods if given. You should identify a minimum of 10 products!

| Product Name | Product | number | warnings | disposal |
|---|---|---|---|---|
| | nail polish remover | | | |
| | oven cleaner | | | |
| | kerosene | | | |
| | gasoline | | | |
| | bleach | | | |
| | furniture polish | | | |
| | paint stripper | | | |
| | paint thinner | | | |
| | oil based paint | | | |
| | drain cleaner | | | |
| | weed killer | | | |
| | degreaser | | | |
| | rug cleaner | | | |
| | metal polish | | | |
| | rust remover | | | |
| | car wax | | | |
| | wood preservative | | | |
| | antifreeze | | | |
| | motor oil | | | |
| | insect repellent | | | |
| | pest strips | | | |
| | batteries | | | |
| | laundry detergent | | | |
| | dish washing detergent | | | |
| | spray cleaners | | | |
| | others | | | |



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# USE SAFER SUBSTITUTES

## Reduce It—Don't Produce It!

| | |
|---|---|
| Ant Control | Pour a line of cream of tartar (a spice found in grocery stores) at the place where they enter the house. The ants will not cross over it. Sprinkle red chili pepper, paprika, and/or dried peppermint where ants are entering the house. |
| Air Freshener | Leave an opened box of baking soda in the room. Add cloves and cinnamon to boiling water and then simmer. Use fresh flowers and herbs. |
| Insecticide Alternatives | Stripping old fruit from the vines and trees will keep insects from laying their eggs in the old fruit, thus decreasing the number of baby insects in the garden. Use products like Dipel® for tomato hornworm. Dipel® causes a disease only in specific pests and is harmless to humans and pets. |
| Chemical Fertilizer Alternative | Compost leaves, grass clippings, and other organic waste. Spread around the base of plants. |
| Cleanser (Porcelain Cleaners) | Dip damp cloth in baking soda and rub over stains. You can also make a paste with water and baking soda and apply it to stained surfaces. Allow to set before rubbing clean and rinsing. |
| Copper Cleaner | Pour vinegar and salt over copper and rub. |
| Drain Opener | Prevent clogging by using a drain strainer. Use plunger or mechanical snake. Pour 1/2 cup (125 ml) baking soda into the drain followed by two cups (500 ml) of boiling water. Flush drain weekly with boiling water for prevention. |
| Flea and Tick Repellent | Feed pets brewer's yeast, vitamin B, and garlic tablets. Herbs such as fennel, rue, and rosemary repel flies. Place eucalyptus seeds and leaves around the area where the animal sleeps. |
| Furniture Polish | Use small amount of mayonnaise and soft cloth. Mix three parts olive oil and one part vinegar and use soft cloth. Mix one part lemon juice with two parts olive oil or vegetable oil and use soft cloth. |
| General Cleaner | Mix three tablespoons (45 ml) baking soda with one quart (950 ml) warm water. |
| Insect Repellent | Blend six cloves crushed garlic, one onion (minced), one tablespoon (15 ml) dried hot pepper, and one teaspoon (5 ml) soap in one gallon (4 l) of water. Let set one to two days. Strain and spray. |
| Japanese Beetles | Pheromone traps are available which attract Japanese beetles into a container for disposal in your household trash. |

95



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## USE SAFER SUBSTITUTES
(continued)

| | |
|---|---|
| Laundry Detergent | Select a nonphosphate detergent, use baking soda or soap in place of detergent. Make a paste of baking soda and water for dirty spots. |
| Linoleum Floor Cleaner/Wax | Mop with one cup (250 ml) white vinegar with two gallons (7.6 l) of water to remove dull, greasy film. Polish with club soda. Adding sour milk or skim milk to rinse water will shine the floor without polishing. |
| Mosquito Repellent | Drink brewer's yeast or take in tablet form on a daily basis during summer months. (NOTE: Some people are allergic to it, so make sure you are not allergic to brewer's yeast before taking it by putting a little in your mouth, swirling it around, and spitting it out. If you get any reactions, do not take brewer's yeast.) |
| Mothballs | Place cedar chips around clothes. Dried lavender can be made into sachets and placed in drawers and closets. |
| Oven Cleaner | Sprinkle salt on spills when they are warm and scrub. Mix three tablespoons (45 ml) baking soda with one quart (950 ml) warm water. Use non-stick or Teflon® oven liners (reusable trays) to catch spills. Rub gently with steel wool. |
| Cockroaches | Set out a dish of equal parts baking soda and powdered sugar. Set out a dish of equal parts oatmeal flour and plaster of paris. Put some grease or petroleum jelly on the inside of a jar that contains a banana. Set a tongue depressor or emery board near the jar to serve as a ramp. The cockroaches will be trapped inside the jar. Place bay leaves around cracks in the room. |
| Snail and Slug Killer | Fill a shallow pan with stale beer and place in the infested area. Overturn clay plots and the snails will seek shelter in them from the heat. The snails can then be collected. Lay boards between rows of planted vegetables. The snails often attach themselves to the boards and can be collected. |
| Upholstery Cleaner | Clean stains immediately with club soda. Club soda will also remove spots on rugs. |
| Window Cleaner | Mix 1/2 cup (125 ml) white vinegar with one gallon (3.8 l) warm water. Use newspapers to dry the glass. Use lemon juice and dry with a soft cloth. |
| Wood Floor Wax/Cleaner | Mix equal parts of cooking oil and vinegar. Apply in a thin coat and rub in well. Painted wooden floors can be washed with one teaspoon (5 ml) baking soda and one gallon (3.8 l) hot water. Rinse with clean water. |

96



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# HOUSEHOLD HAZARDOUS WASTE CHART

The following chart will help you establish the most effective means of disposing typical hazardous wastes used around your home or garden. **Black dots (•)** indicate products which can be poured down the drain with plenty of water. If you have a septic tank, additional caution should be exercised when dumping these items down the drain. In fact, there are certain chemical substances that cannot be disposed of in a septic tank. Read the labels to determine if a product could damage the septic tank. **Diamonds (◊)** indicate materials which cannot be poured down the drain, but can be safely disposed in a sanitary landfill. Be certain the material is properly contained before it is put out for collection or carried to the landfill. **Triangles (Δ)** indicate hazardous wastes which should be saved for a community-wide collection day or given to a licensed hazardous wastes contractor. (Even the empty containers should be taken to a licensed contractor if one is available.) **Pound signs (#)** indicate recyclable material. If there is a recycling program in your area, take the materials there. If not, encourage local officials to start such a program.

| | Type of Waste | • | ◊ | Δ | # |
|---|---|---|---|---|---|
| Kitchen | Aerosol cans (empty) | | ◊ | | |
| | Aluminum cleaners | • | | | |
| | Ammonia-based cleaners | • | | | |
| | Bug sprays | | | Δ | |
| | Drain cleaners | • | | | |
| | Floor care products | | | Δ | |
| | Furniture polish | | | Δ | |
| | Metal polish with solvent | | | Δ | |
| | Window cleaner | • | | | |
| | Oven cleaner | | ◊ | | |
| Bathroom | Alcohol-based lotions (aftershaves, perfumes, etc.) | • | | | |
| | Bathroom cleaners | • | | | |
| | Hair removers | • | | | |
| | Disinfectants | • | | | |
| | Permanent lotions | • | | | |
| | Hair relaxers | • | | | |
| | Medicine (expired) | • | | | |
| | Nail polish (solidified) | | ◊ | | |
| | Nail polish remover | | ◊ | | |
| | Toilet bowl cleaner | • | | | |
| | Tub and tile cleaner | • | | | |
| Garage | Antifreeze | • | | | # |
| | Automatic transmission fluid | | | Δ | # |
| | Auto body repair products | | ◊ | | |
| | Battery acid (or battery) | | | Δ | # |
| | Brake fluid | | | Δ | |
| | Car wax with solvent | | | Δ | |
| | Diesel fuel | | | Δ | # |
| | Fuel oil | | | Δ | # |
| | Gasoline | | | Δ | # |
| | Kerosene | | | Δ | |

## HOUSEHOLD HAZARDOUS WASTE CHART
**(continued)**

| | Type of Waste | • | ◊ | Δ | # |
|---|---|---|---|---|---|
| | Used motor oil | | | Δ | # |
| | Windshield washer solution | • | | | |
| Workshop | Paintbrush cleaner with solvent | | | Δ | # |
| | Paintbrush cleaner with TSP | • | | | |
| | Aerosol cans (empty) | | ◊ | | |
| | Cutting oil | | | Δ | |
| | Glue (solvent-based) | | | Δ | |
| | Glue (water-based) | • | | | |
| | Paint (latex) | | ◊ | | |
| | Paint (oil-based) | | | Δ | |
| | Paint (auto) | | | Δ | |
| | Paint (model) | | | Δ | |
| | Paint thinner | | | Δ | # |
| | Paint stripper | | | Δ | |
| | Paint stripper (lye-based) | • | | | |
| | Primer | | | Δ | |
| | Rust remover (with phosphoric acid) | • | | | |
| | Turpentine | | | Δ | # |
| | Varnish | | | Δ | |
| | Wood preservative | | | Δ | |
| Garden | Fertilizer | | ◊ | | |
| | Fungicide | | | Δ | |
| | Herbicide | | | Δ | |
| | Insecticide | | | Δ | |
| | Rat poison (rodenticide) | | | Δ | |
| Miscellaneous | Ammunition | | | Δ | |
| | Artists' paints (mediums) | | | Δ | |
| | Dry cleaning solvents | | | Δ | # |
| | Fiberglass epoxy | | | Δ | |
| | Gun cleaning solvents | | | Δ | # |
| | Lighter fluid | | | Δ | |
| | Mercury batteries | | | Δ | |
| | Moth balls | | | Δ | |
| | Old fire alarms | | | Δ | |
| | Photographic chemicals (unmixed) | | | Δ | |
| | Photographic chemicals (mixed and properly diluted) | • | | | |
| | Shoe polish | | ◊ | | |
| | Swimming pool acid | | | Δ | |

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**Joan McAuley** – St. John Nepomucene School, Parma, OH
**Joan Borovicka** – St. John Nepomucene School, Parma, OH

**OVERVIEW:**

The intent of the lesson is to realize that our water supply is fragile. Water is needed for life. It is a limited resource in many parts of the world. The water we drink today is the same water that dinosaurs drank many years ago. The water cycle has purified it repeatedly. About 97.2% of the earth's water is found in the oceans. Icecaps and glaciers account for 2%, groundwater is .62%, freshwater lakes are .009% and other areas total .009%.

**PREREQUISITE:**

SKILLS: Use of measuring cups, metrics, and graduated cylinders.
Use of pipit or eye dropper.
Comparison of fractions and/or percentages.
KNOWLEDGE: Background information about water.

**MATERIALS:**

Per Class: One Inflatable soft globe.
Per 5 Student group:
1 one gallon container
1 set of Metric measuring cups
5 plastic glasses
Water
1 Pipit or eyedropper

Student journals or notebooks

**ANTICIPATED STUDENT OUTCOMES:**

1. Students will demonstrate on a small scale the amount of water available on earth for humans.
2. Students will recognize the limited amount of water available.
3. Students will recognize the need to conserve water.
4. Students will share information with others.

**CONNECTIONS TO PROFICIENCY TEST**:

Math: Solve problems, make applications using percentages and fractions.
Science: Draw conclusions from a conceptual model based on a given set of data.

**INTRODUCTION**: (10 Min)

Have students catch inflatable globe tossed by teacher. Note where the right thumb is located on the globe: land or water. Record results on board. Repeat at least 20 times. Figure fractional amount and/or percentages of land stops and water stops. It should be about 75% water. This will serve as intro to the idea of how much of the earth's surface is covered by water.

**EXPLORATION**: (3OMin)

1. Ask students to fill a gallon jug with water. This represents the total amount of water on our planet. (About 3,780 ml.)
2. Remove 112 ml from the gallon amount. This represents the total supply of fresh water in the system. Place this amount in a clear cup and compare to the gallon.
3. From the 112 ml each group of students should remove 87 ml and place it in a second clear cup. This represents the water that is locked up in polar ice caps, glaciers, topsoil, and suspended in the atmosphere. Set this aside.
4. Using a dropper or pipit remove one drop from the remaining amount and place it in a test tube. This drop represents the fresh water supply that is available to be used by man.
5. There are 34 ml remaining. This amount represents costly, inaccessible, and polluted water.

**DEBRIEFING**: (10 Min)

1. Have students record demonstration in journals.
2. In groups discuss how this information impacts their ideas about water, conservation and related ideas.
3. Share conclusions from each group.
4. Share information with classes in other parts of the country and/or world. Use Science Across the World as a link to others globally or to other classes in different parts of the United States. This is a partnership project between BP and John Carroll University.

**EXTENSIONS:**

1 Read and discuss Activity 12 from Environmental Science Activities Kit by Michael L. Roa. Use questions from the article to generate group discussion in cooperative learning sessions. Follow up with the survey sheet on Personal Water Use. Next day, share information. Calculate class average for each category. Discuss information generated. Share thoughts from individual groups.

2. Do the Home Water Conservation Survey.

**RESOURCES:**

Book: Roa, Michael L. Environmental Science Activities Kit. New York: The Center for Applied Research in Education.

This book is used to supply the teacher with background information as well as the students. It also includes the hand-outs on the Personal Water Use and the Home Water Conservation Survey.

**OTHER RESOURCES:**

Hands-on activities and more background information can be found in;

A Primer on Fresh Water. Canada: Environmental Citizenship. 1993.

From the Mountains to the Sea. Canada: Environmental Citizenship. 1993.

Wasserman, Pamela and Anne Scullard. Counting on People. Fayetteville, NC: Worth Printing, Inc., 1994.

## I 2.1 "Water" We Going to Do?: Background Information

Water is a precious resource. Without water, life itself would be impossible. All plants and animals need water. Most of us, however, take an abundant supply of clean fresh water for granted.

While most of us are aware of the water that we use in our homes, the amount of water used by industry is enormous. Table 12-A shows the amount of water used to produce various products in the United States. Table 12-B shows the percentage of water consumed by different uses in the United States. When studying Table 12-B, note that it is for water "consumed." This is the water that is not returned to the surface water or underground water system. Water used to cool electricity-generating plants accounts for 38 percent of the water used in the United States, but it is not consumed.

**TABLE 12-A**

Gallons of water typically used to produce various products in the United States:

| | | | |
|---|---|---|---|
| 1 automobile | 100,000 | 1 pound of grain-fed beef | 800 |
| 1 ton of brown paper for bags | 82,000 | 1 pound of rice | 560 |
| 1 pound of cotton | 2,000 | 1 pound of steel | 25 |
| 1 pound of aluminum | 1,000 | 1 gallon of gasoline | 70 |

**TABLE 12-B**

Percentage of water consumed by various uses in the United States:

| | | | |
|---|---|---|---|
| Irrigation | 60% | Industry | 13% |
| Rural domestic use | 59% | Power plant cooling | 2%. |
| Urban domestic and business | 29% | | |

It has been estimated that between 30 percent and 50 percent of the water used in the United States is wasted. Many water experts believe that conservation is our cheapest, quickest, and best source of water in the near future.

As our demand for water increases due to population increases and additional demand for various products, our water problems will increase. Even many areas that currently seem to have abundant water may well experience water shortages in the coming decades. Droughts are always a possibility, and even without droughts, there is not an infinite amount of water available.

Since most of the water used in the United States is not used in our homes, it may seem that we can do nothing about its use. We must keep in mind that industries use the water to produce the products we purchase. If we don't demand a new car every two years, if we recycle as much as possible, and if we don't waste food and other materials, water will be saved.

a new car every two years, if we recycle as much as possible, and if we don't waste food and other materials, water will be saved.

We can also encourage conservation of water by industries by legislative action. Laws can be passed to require water conservation equipment and methods. Federal and state subsidies that encourage waste of water can be eliminated or reduced.

Learning where we use water in our homes can help us learn where we can best conserve water. Table 12-C shows the percentage of water used for various uses in a typical home in the United States.

**TABLE I 2-C**

Domestic uses of water in the United States:

| | | | |
|---|---|---|---|
| Toilet flushing | **40%** | Laundry | **4%** |
| Washing and bathing | **37%** | Household cleaning | **3%** |
| Kitchen use | **7%** | Garden | **3%** |
| Drinking | **5%** | Cleaning car | **1%** |

Notice that reducing the amount of water used in toilet flushing by only 10 percent would save as much water as is used for laundry and save almost as much as is used for drinking. Using a water-saving toilet cuts water used for flushing from about 6 gallons per flush to about 1.5 gallons-a savings of 75 percent!

Water pollution is a problem even in communities that have adequate supplies of water. This makes the wise use of the available clean fresh water even more important.

Aside from concerns about shortages of water for human consumption, we should be concerned about water use because of the impact it has on the environment. When reservoirs are built, valleys are flooded and downstream rivers are changed. **Channelizing** of streams destroys the riparian communities along their banks. Diverting water from one area to another via canals or pipes damages the environment from which the water was taken as well as the areas through which the canals and pipes pass.

Conserving water makes sense-environmentally, financially, and ethically!

Name _____ Class _____ Date _____

# 12.4 "Water" We Going to Do?: Questions

**(Answers below)**

1. What is the major use of water in the United States? _____

2. What is the major use of water in the home? _____

3. In your daily life, how can you reduce water used in the following areas?

   a. agriculture

   b. manufacturing

   c. electrical generation

4. Should we be growing crops such as alfalfa, cotton, and rice in areas such as California and Arizona where there is not enough naturally available water for them? Why or why not?

5. Why is it important to conserve water at home?

6. List several ways to conserve water at home.

**Discussion:**

1. How much water would be wasted in a year if everybody in this class had a faucet leak similar to the one we simulated in class?
2. How much water would be saved per year if all of those leaky faucets were fixed?
3. In what ways does saving water save energy?
4. What accounted for most of the water used in the home?
5. What were the most common places where water was being wasted in the home?
6. How can water be conserved in the yard?
7. How can we influence others to save water?

**Answers to 12.4 "Water" We Going to Do?: Questions**

1. Agriculture is the major water user in the United States.
2. Flushing toilets is the major water use in most homes.
3. a. Water can be conserved in agriculture by planting crops in areas where the rainfall or naturally available water is adequate to grow them and by using drip irrigation, mulching and other methods. *(Other answers are acceptable.)*

   b. Water can be conserved in manufacturing by recycling water that is used and by developing less wasteful processes. *(Other answers are acceptable.)*

c. We can reduce the water needed for electrical generation by reducing our demand for electricity. There are many ways to reduce electrical consumption. *(Other answers are acceptable.)*

4. Answers will vary. Point out that governmental subsidies make such practices possible. Also discuss the demand created by both lifestyle and population.
5. Saving water at home saves money and energy as well as water. It helps develop a conservation ethic or conserving attitude. It makes water available for other uses. *(Other answers are acceptable.)*
6. See the Home Water Conservation checklist. Other answers are acceptable.
7. Building reservoirs to supply water floods valleys and changes water flow down-stream. Taking water from one area to another via pipes or canals deprives one area of its water as well as affects the area through which the pipes and canals pass.

105

## 12.2 "Water" We Going to Do?: Personal Water Use

**Water Use:**

Your class has listed various ways that water is used in the home. Before actually recording how much water you use in a day and a week, record how much you think you use.

I think I use about _____ gallons per day and _____ gallons per week.

**Water Use:**

For the next 24 hours, keep track of the actual ways that you use water and the number of times you use water each way. You can use the estimated amounts per use or you can actually measure the amount of water used.

**WATER USAGE AMOUNT**

| WATER USE | TIMES PER DAY | ESTIMATED GALLONS ** | MEASURED GALLONS | PER DAY | PER WEEK | TOTAL USAGE |
|---|---|---|---|---|---|---|
| Bathing | | 30 (1) | | | | |
| Showering | | 50 (2) | | | | |
| Toilet Flush | | 5 (3) | | | | |
| Wash face/hand | | 2 (4) | | | | |
| Getting a drink | | 1 (5) (6) | | | | |
| Brushing teeth | | 2 (4) | | | | |
| Cooking | | 10 (7) | | | | |
| Washing clothes | | 60 (8) | | | | |
| Washing dishes | | 30 (9) | | | | |
| Other | | | | | | |
| GRAND TOTAL | | | | | | |

**Notes on Estimated Gallons:

(1) Depends on how full the tub is
(2) 25 Gallons with low-flow head
(3) 1.5 gal with water-saver toilet
(4) 2 gallons if you turn the water off
(5) Includes running water to cool it
(6) .25 if you turn water off
(7) Per supper, including rinsing
(8) Large load
(9) 10 gallons with dishwater; or using two 5-gallon dishpans

## 12.3 "Water" We Going to Do?: Home Water Conservation Survey

Use this form to survey your home for water use. Use the space provided to add an additional question in each category. If the answer is sometimes yes or sometimes no, mark the one that is usually true.

### INDOORS:

**Bathrooms:**

Yes ___
No ___ Have toilet tanks been checked for leaks?

*(To check for leaks, place a few drops of food coloring in toilet tank. If color is seen in bowl without flushing, there is a leak in need of repair.)*

Yes ___
No ___ Are tissues disposed of in the toilet? (Use wastebasket for tissues.)

*Each flush uses up to 7 gallons of water, depending on the type of toilet.*

Yes ___
No ___ Is there a plastic bag or "dam" in the toilet tank, or do you have a low-flush toilet? (Low flush uses only 1-5 gallons per flush).

*(Put a small amount of clean sand or pebbles in the bottom of a plastic Bottle or bag and fill it with water. Cap the bottle or tie the bag. Place in the toilet tank, SAFELY AWAY from all moving parts.*

Yes ___
No ___ Is there a leaky faucet in the sink or shower?

*Can be repaired by tightening fixture or replacing washer in faucet.*

Yes ___
No ___ Are family members taking short showers? (5 minutes or less)

*(Taking shorter showers can save up to 8 gallons of water per minute.)*

Yes ___
No ___ Do you have low-flow shower head and flow restrictors?

*(Low-flow shower heads and flow restrictors greatly reduce water use, as well s save money and hot water too.)*

**Kitchen and Laundry:**

Yes ___
No ___ Are there leaky faucets?

*(Tighten the faucet or replace the washer.)*

Yes ___
No ___ Are there flow restrictors on the faucets?

*(Flow restrictors easy to install; save water, energy and money.)*

107

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Yes ___
No ___

Are dishwashers and washing machines turned on only when full?

*(Wait for full load. Use water and energy-saving cycles.)*

Yes ___
No ___

Do you rinse vegetables with the water running?

*(Rinsing vegetables in a bowl or stoppered sink saves water. Rinse water can be used to water plants.)*

**Outdoors:**

Yes ___
No ___

Have all outdoor faucets been checked for leaks?

*(Small leaks can add up to large losses. Replace leaky washers.)*

Yes ___
No ___

Are lawns and plants watered only when they really need it?

*(Check lawns and shrubs to see if they need water. A lawn that springs back after being stepped on doesn't need water. Devices can be purchased to test for soil moisture. Turn automatic sprinklers off in the rainy weather.)*

Yes ___
No ___

Do you use drought-tolerant plants in your landscaping?

*(Landscaping with drought-tolerant plants can reduce both water use and maintenance in your yard. Consult a local nursery.)*

Yes ___
No ___

Do you water plants and lawns early in the morning or late in the evening?
*(Watering in the hot part of the day wastes water because of evaporation.)*

Yes ___
No ___

Do you use a hose to clean driveways and sidewalks?

*(Use a broom. It does the job just as well.)*

Yes ___
No ___

Do you use a bucket to wash the car?

*(Using a hose wastes water. At least turn the water off when not actually spraying the car. Also, wash car on lawn.)*

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# Water, Water Everywhere – But Not a Drop To Drink

Grade 7-8

**Susan Ploegstra,** Messiah Lutheran School, Cleveland, OH
**Copeland Lauder,** Shaker Heights Middle School, Shaker Heights, OH

**OVERVIEW:**(3 – 4 Forty minute class periods)

Ground water pollution begins at the local level. The how of its source is often not known or understood. In this lesson, students will explore ground water pollution problems, create a model ground sample to help visualize how ground water becomes polluted, and discuss the global problems it creates.

## PREREQUISITES:

The student must be aware of lab safety, writing lab reports, and metric measurements. They must have a working knowledge of the scientific method. A working vocabulary to include the following terminology: pollution, porosity, permeability, water table, infiltration, run-off, ecosystem. A background knowledge of the watercycle, soil horizons, the earth's fresh water amounts versus salt water is also necessary.

## Materials:

### Whole Class:

- For demonstration purposes: Day One - a sample jar of clean water and a sample jar of polluted water.
- A copy of the article "Solubility and the Arctic Bear Hunt".
- Video "The Great Experiment" from the 1996 Films for the Humanities and Science, Princeton N.J.
- Lab sheets – One per student
- Focus activities – One per student

### Per group: ( 4 students per group)

- One liter bottle
- One ring stand
- Prepared color solution
- Soil samples
- Two pieces of filter paper

## Anticipated Student Outcomes

- Improved knowledge of ground water filtration
- Conclusions based on observation of the ground pollution problem
- Importance of pollution prevention due to ground water pollution
- Work cooperatively in groups

**Debriefing**: – 40 minute class period

Focus questions will be given to each lab group. These should be on the same color paper as their original exploration the day before. Students will work with their lab partners to answer the questions for five to ten minutes.

Using the jigsaw method for grouping – new groups will be formed to include one member from each original lab group. There will be four groups of six. Each group must contain six different colors of lab sheets.

Groups will compare color samples, make observations and be ready to share with the entire class their observations. Record all information on Focus activity sheet. Throughout the groups the teacher should circulate from group to group to listen, offer suggestions or give encouragement.

Regroup the class. The teacher should guide the students to the idea of ground water problems locally and globally. Include what scientists are finding in the news. If time, a short portion of the introduction of the video *The Great Experiment* can be shared.

## Extensions:

- Continue the Great Experiment video
- Continue the lab by pouring clean water through to see if it picks up any color left in the soil sample after the first trial. This will show how material will remain in the soil and leach out with other water amounts.
- Internet sites – student visit to Altavista "Ground Water" sights for further information. See also internet resource list for other addresses.
- Video segments from the following could be used. "Cleaning up Toxics at Home" or Pollution (Earth, Environment, and Beyond)

## Teacher Background Information:

1. Teacher code for creating water samples and lab sheets for the exploration lab:

   **Green paper with a water sample of 100mL of water and 2 drops of red food coloring**
   **Red paper with a water sample of 100mL of water and 6 drops of red food coloring**
   **Yellow paper with a water sample of 100mL of water and 8 drops of red food coloring**
   **Blue paper with a water sample of 100mL of water and 10 drops of red food coloring**
   **Orange paper with a water sample of 100mL of water and 12 drops of red food coloring**
   **Purple paper with a water sample of 100mL of water and 14 drops of red food coloring**

## Connections to the Proficiency Test:

- Use and compute with the appropriate metric units
- Read the scale on measurement devices and make interpolations where appropriate
- Draw conclusions
- Distinguish between observation and inferences
- Organize data, identify patterns and trends
- Draw conclusions
- Apply science safety procedures
- Relate the effect on an ecosystem to a given environmental change

## Introduction: – 40 minute class period

*Reading – "Solubility and the Arctic Bear Hunt"*

After the class has read the article divide them into groups of four students. Each group is to come up with suggested answers to the following questions:

1. How did the PCB's get into the Hudson Bay ecosystem when there is very little industry in the bay area?
2. Why did PCB's end up in the bear's fat?

Regroup the entire class for a teacher directed discussion based on group answers. Guide the discussion to the idea of water pollution.

*Demo Activity* – Teacher directed – Using a sample of clean fresh water and a sample of polluted water discuss pollutions who, what, when, where, and why. Direct the students to the next activity.

*Brainstorm* –Direct the discussion so students begin to suggest materials which will cause pollution of water and enter the ground water system. This can be locally and globally. (Examples: detergents, fertilizers, oil, nail polish, etc.)

## Exploration: – 40 minute class period

The students will set up a representative earth sample in the inverted two liter pop bottle following the directions on the lab sheet given. All observations and inferences will be recorded on the lab sheet given.

The lab sheets should be run on a different colored paper for each group (six colors of four each). These will be used during the next day debriefing session.

A water sample will be poured through the sample and observations will be made by comparison of the filter paper used. If available a colorimeter could be used and color analysis could be done with more extensive statistics taken. Questions and comments on the lab sheet should be completed for the debriefing session.

2. **Soil Horizons** –Soil is not the same throughout. As it forms, soil develops different layers called horizons. Soil horizons differ in color, texture and composition. Soil that is still forming does not have distinct horizons. Such soil is termed immature. Soil that has been forming long enough to have distinct horizons is termed mature. Horizon A is commonly called topsoil. Topsoil is rich in humus, giving it is dark color. It is in this horizon that lawns and gardens are planted. After every rain, water soaks through Horizon A. Minerals and tiny clay particles are washed down to lower layers in a process called leaching. Horizon B is often referred to as subsoil. The materials leached out of Horizon A are deposited here. Horizon B is rich in clay. It has less humus than Horizon A. It is usually brown or tan. Horizon C is made of partly weathered rock. It consists of the cracked and broken surface of bedrock. Bedrock is the solid rock beneath the surface.
3. **Ground water/water cycle-** The exchange of water among the earth's water, land, and air is the water cycle. Ground water is the earth's underground water supply.
4. **Major pollutants of freshwater** – See handout
5. **PCB's** - See Handout.

## Resources:

***Books***

- Environmental Resource Guide–Air Waste Mgmt. Asso., Pittsburgh, PA
- Opposing Viewpoints, Greenhaven Press, 1991
- Environment Events – Assessment and Response – N & N Publishing Co., Inc. New York, 1993
- Szumski, Bonnie, *Toxic* Wastes, Greenhaven Press, 1989
- Activities for the Changing Earth System. Earth Systems Education, Ohio State University, 1993
- From the Mountains to the Sea: A Journey in Environmental Citizenship. Environment Canada, 1993.

***Articles:***

- "Solubility and the Arctic Bear Hunt" by Dr. Malcolm Ramsay, University of Saskatchewan

***Software:***

- CD ROM National Geographic, *Earth's Endangered Environment*

***Internet:***

- Altavista "Ground Water"
- NTTI Websight http://www.wnet.com
- Bill Nye the Science Guy http://nyelabs.kcts.org/.
- Water Programs for older students:
- http://www.cs.brown.edu/courses/cso92/pr/oiects/water/
- Science Learning network www.sln.org
- Science Lab www.abc.net.au/science/default.htm.
- Environmental education www.envirolink.org/enviroed.

## LAB EXPLORATION:

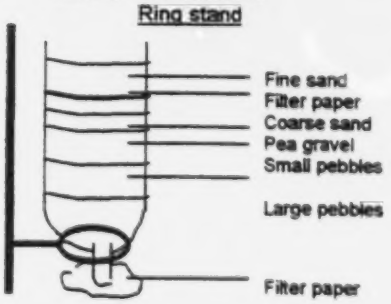
Investigation: WATER, WATER EVERYWHERE AND NOT A DROP TO DRINK

Objective: To observe what happens to polluted water that seeps into the ground and how it affects the ground water.

Question: What do you think happens to ground water that seeps into the ground?

Materials
2 liter bottle with bottom cut off.
Rubber band
150ml large pebbles
200ml small pebbles
150ml pea gravel
600ml coarse sand
600 fine sand
2 beakers 100ml or larger
ring stand
100ml water sample ( teacher provided )
pen/pencil
stapler
scissors

Procedure:
Collect supplies as listed.
Set up ring stand and place the empty bottle in the ring after rubber banding your filter paper to the pouring end.
Place the soil samples in measured amounts in the inverted bottle as shown.




Pour the colored water sample over the sand and let it filter through. Allow 5 minutes for this process.
Measure the drainage water at the end of 5 minutes.
Take out the filter paper from under the top layer. Cut it into four pieces, staple it to your lab card and label. Repeat with your bottom filter ( the rubber band section). Cut into four pieces and staple one piece to your lab report. Continue with questions/observations.

**Lab Card:**

Draw and label an illustration of your soil sample below.

Staple filter samples here.

Top filter sample———————— Bottom filter sample————————

Record the amount of water poured————amount of water collected————

1. Why do you think the layers were placed in the order given?

2. Did all the water run through the ground sample? How could you tell?

3. What was the color of the water that drained out? Was it different from your original sample?

4. Why or Why not?

5. Explain why the amount of water which drained through is less than the amount poured in.

6. How is the soil like a man made filter?

7. If the soil is a filter why should we be concerned about pollutants getting into the ground water?

8. True or false? The type of rock makes no difference in the amount of pollutants found in ground water. Why? Explain:

9. Explain the meaning of concentration and dilution as they relate to water pollution.

10. Give a mathematical explanation to: 8 parts per million of PCB were found in the tissues of a polar bear.

11. Explain how it is possible for PCB from a factory here in Cleveland to end up in the tissues of a dolphin found just off shore the island of Jamaica.

# Solubility and the Arctic Bear Hunt

**In northern Canada, a helicopter hovers over the snow. Dr. Malcolm Ramsay leans out of the doorway to keep a polar bear in sight. As Ramsay braces and aims his rifle, the bear lumbers through the snow trying to escape. Ramsay fires, and the bear runs faster.**

Ramsay, who is an ecologist, signals the pilot to land in a clearing. He unloads his equipment, then shields his face from the helicopter-[illegible] snowstorm as the pilot departs. By the [illegible] Ramsay reaches the bear, the tranquilizer-[illegible] dart has done its job, and the animal lies [illegible] in the snow.

[illegible] Ramsay begins a physical examination that [illegible] take hours. With a net, ropes, and a tripod, [illegible] bear is winched into the air to be weighed. [illegible] syringes are filled with blood samples. A [illegible] is extracted; its growth rings will tell the [illegible]'s age. An electronic instrument records [illegible] body's resistance to electricity, which is an [illegible] of the bear's muscle-to-fat ratio. A [illegible] of fat tissue is taken. By the time the [illegible] begins to stir, Ramsay has packed his gear [illegible] is waving to the returning helicopter. The [illegible] bear will resume its migration to Hudson [illegible] generally unharmed by the encounter.

The tissue samples are sent to a laboratory [illegible] analysis. The results Ramsay gets from the [illegible] are worrisome. The bear's fat tissue contains [illegible]chlorinated biphenyls, better known as [illegible]. This family of synthetic organic [illegible]pounds has been used industrially in electrical and mechanical equipment for decades. Originally scientists believed that PCBs were biologically inert, but in the 1970s they discovered that laboratory animals exposed to PCBs had higher than normal rates of birth defects and liver cancer.

Ramsay has found that the concentration of PCBs in the bear's fat tissue is 8 ppm (parts per million). So far, this concentration of PCBs has caused the bear no apparent harm. But scientists are concerned about the polar bears because the way that PCBs dissolve in fat makes it possible for the concentration to increase in the bears even if the amount of PCBs in the environment does not change.

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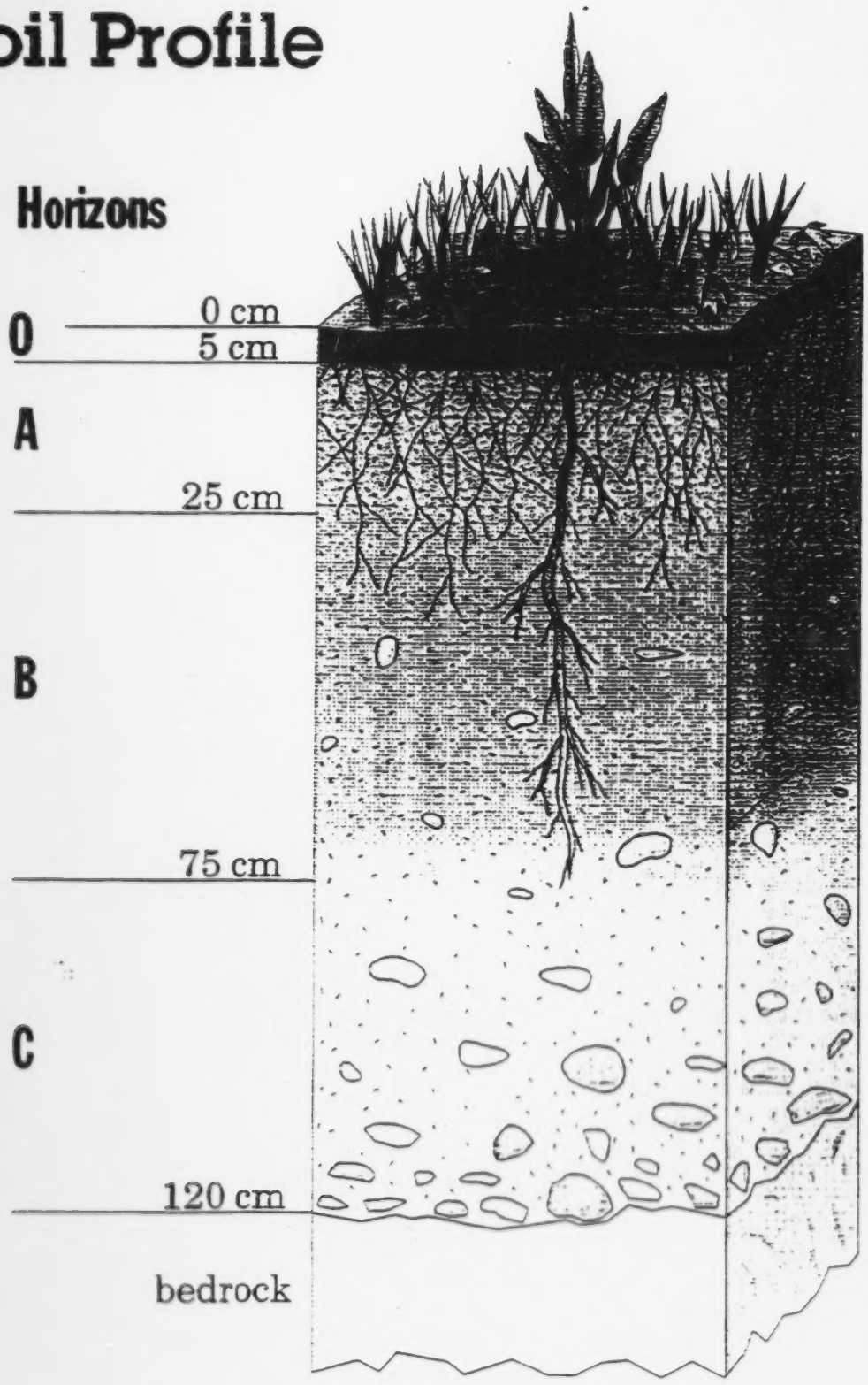
# A Soil Profile




116



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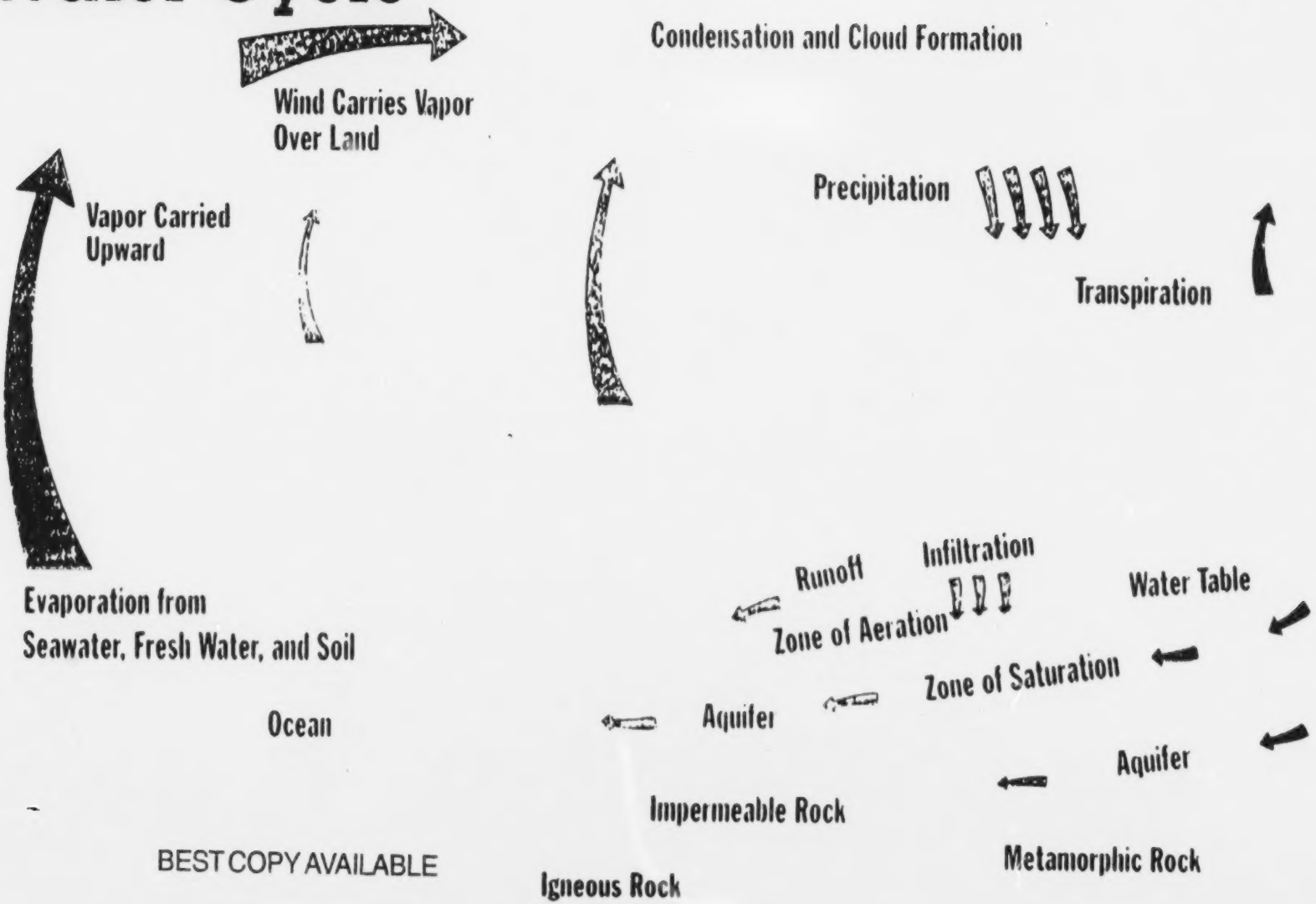
# Water Cycle

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## Major Pollutants of Fresh Water

| CAUSE OF POLLUTION | CONSEQUENCES OF POLLUTION |
|---|---|
| **Organic Matter**<br>• Sewage from towns and cities.<br>• Slurry from farm. | Increased levels of nitrates and phosphates cause growth of algae and bacteria, which use up the dissolved oxygen in the water, which fish need for survival. |
| **Sediments**<br>• Natural erosion of hills and river banks.<br>• Waste products from mines, construction areas, and farms. | Silting up of rivers and streams, which become slow-moving and thus fertile breeding grounds for disease-carrying organisms. Burying of river and lake beds in deep layers of sediment, some of which is contaminated with toxic material. |
| **Toxic Waste**<br>• Metals, petrochemical products, solvents, heavy metals, and minerals from industrial areas.<br>• Some organic industrial waste.<br>• Storm water containing household detergents. | Poisoning of fish and other water organisms. Illness in humans. |
| **Farm and Garden Chemicals**<br>• Fertilizers and pesticides used on farms, in gardens, on golf courses, and in parks. | Build-up of pesticides in organisms, which become more concentrated in the bodies of animals near the top of the food chain, such as large fish, otters, birds, and humans. |
| **Disease-Carrying Organisms**<br>• Bacteria found in sewage build up rapidly in slow-moving and still water such as ponds, ditches, and lakes.<br>• Mosquitoes, which breed in still water. | Illness in humans caused by bacteria. Spread of diseases like malaria by mosquitoes. |





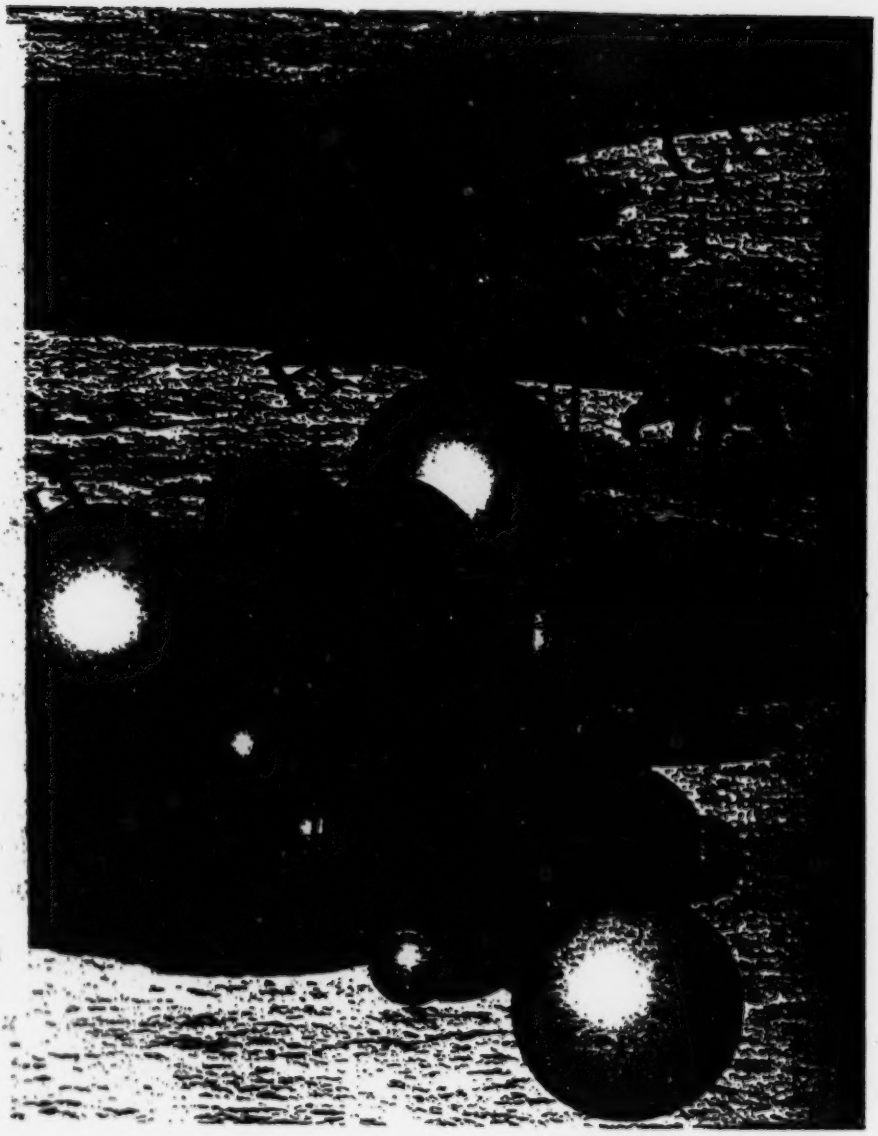
811

## Story Background

Dr. Malcolm Ramsay is a professor of vertebrate ecology at the University of Saskatchewan and one of Canada's leading experts on polar bears. He focuses on polar bears because Arctic ecological interactions are simple to study. Also, polar bear tissue clearly demonstrates biological amplification of pesticides because polar bears are at the top of the food chain. The polar bear's food chain consists of algae, which absorb PCBs from polluted water; plankton, which eat algae; cod, which eat plankton; seals, which eat cod; and finally polar bears, which eat seals. At each link in the food chain, the concentration of PCBs creases.

There are more than 209 different oily synthetic polychlorinated biphenyl compounds (PCBs). Most are insoluble in water, soluble in fats, and resistant to biological and chemical degradation. These properties result in the biological amplification of PCBs.

Although now banned in North America and Western Europe, PCBs are still used in Eastern Europe. The long range effects of PCBs and their more toxic furan impurities on people are unknown. However, in laboratory animals, high doses of PCBs produce gastric disorders, birth defects, bronchitis, miscarriages, skin lesions, hormonal changes, liver and kidney damage, and tumors.



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**Anna Micko** – St. Rose of Lima Middle School, Cleveland, OH
**Maureen Vazzano** – St. Jude Middle School, Lorain, OH
**Thomas Wilson** – Carl F. Shurer Middle School, Cleveland, OH

**OVERVIEW:** The intent of the lesson is for the student to discover the impact of light, pH, temperature, and pollutants on the quality of life in water.

**PREREQUISITES:**

Skills:
- collecting and labeling samples
- measuring in metrics
- use of microscope, making wet and dry mount slides
- testing for pH
- drawing and writing to record observations

Knowledge:
- pH
- the spectrum of light
- read a Celsius thermometer
- micro-organisms found in water habitats
- kinds of pollution

**MATERIALS FOR EACH GROUP OF FOUR STUDENTS:**

- jars for collecting water samples
- four coffee can lids with wire attached for suspending in water, painted with permanent paint - 1 each, red, yellow, blue, green
- net to collect water life
- observation buckets
- field guides
- thermometers
- microscopes, slides, cover slips, droppers
- pH paper, or kit if available
- coffee filters or filtration papers
- petri dishes or margarine tubs
- scissors
- paper, pencil
- worksheets

**ANTICIPATED STUDENT OUTCOMES:**

1) Students will explore the relationship between the amount of light that is absorbed and the types of living organisms in water.

2) Students will explore temperature of water in relationship to viability of living organisms.

3) Students will explore the impact of pH level of water on living organisms.

4) Students will relate the amount of particulate matter found in the water to size, type, and variety of living organisms.

**CONNECTIONS TO PROFICIENCY TEST:**

Ninth grade proficiency outcomes:

Science: Distinguish between observation and inference
Organize data, identify patterns and trends
Draw conclusions and/or recognize a conceptual model based on a given set of data
Select a device and report data in appropriate units for a specific measurement. Make inferences about the causes of variation in experimental results
Predict the results of various processes that change the earth
Describe chemical and physical interactions
Identify interrelationships of organisms within an ecosystem16
Relate the effect on an ecosystem to a given environmental change.

Math: Select and compute with appropriate standard or metric units
Convert, compare, and compute with common units of measure within the same measurement system
Read the scale on a measurement device to the nearest mark
Compute averages

**INTRODUCTION:**

Students will be informed that the local water source may carry harmful pollution. Their responsibility is to determine if it is polluted and if the pollution is at a harmful level. Teachers may use the activity, "Grave Mistake" found in Project Wet as an introductory activity.

**EXPLORATION:**

(This lesson may take up to five days and can be extended over the course of a school year.)

One day on site. Two or three days to run experiments with water samples.

1) The students will be put into work groups. A water source is needed for the lesson. Ideally a pond, creek, lake, stream, or some natural environment in order to bring a bucket of water from one or more of these sources to the classroom. If at a water site, assign each group an area to explore, e.g. shady area vs. full sun. Students will record observations. What do they see? What do they smell? What do they hear? Is there anything unusual about their sight?

2) Take and record temperature in Celsius at top, middle, and bottom of water plot.

3) Take colored circles and slowly lower into water. Which colors can you see at the top, middle, and bottom of the water plot? Record observations and use meter sticks to measure and record depth at which each color can no longer be seen in the water.

4) Use net to collect and identify large animal life at water site.

5) Collect 3 water samples to bring back to school for further investigations. Label each sample with depth at which it was collected.

6) Make wet mount slides using water samples. Draw any visible organism. Use the chart to identify organisms.

7) Test the pH of each water sample, and record whether the samples are acid or base.

8) Cut circles of filter paper to fit petri dish or margarine tub. Label according to sample. Put 25 mL of water sample in labeled dish. Allow water to evaporate undisturbed. Record observations daily. When completely evaporated, use hand lens to observe particulate matter on filter. Record. Make dry mount slides using particulate matter. Draw observations.

**DEBRIEFING:**

1) On site - What did you see? What did you smell? What did you hear? Did your observations match your collections? Why might your observations be different from your actual samples? Why would the physical environment impact on the visible organisms? Was their any visible pollution at your site? Where might the source of pollution come from? What other factors might impact your site?

2) What colors were absorbed or reflected at the various depths? Did you notice any patterns? What did you notice about the relationship between the colors and the organisms, or lack thereof, at your site? Was there any color that was completely absorbed? Which organisms did you find where you were able to see a specific color? Why would some colors be totally absorbed and others totally reflected? Were some colors prevented by the amount of pollution?

(3) At school - What did you notice about the temperature in your study site? Similarities? Differences? Organisms found? Based upon your temperature findings, is your water site healthy? Why or why not? What other signs gave you an indication that your site was a healthy or an unhealthy environment? What organisms did you observe on your slides? What pollutants did you find? Where may they have come from? What do you know about the location of your site? Does that make a difference? Would the location of the water source determine the type of pollutants? E.g. if the water source is located near an industrial area.

Similar questions can be adapted for the pH test.

4) What did you observe on the filter paper after the water had evaporated? Are the particles similar to the organism you first observed? Why/why not? Is there more particulate matter at certain depths? Why/why not? Would your site location have any effect on the particulate matter? What were you able to identify? Where did this matter come from?

5) You have explored light, temperature, pH value, and particulate matter in various samples of water from various sites. Is the water at those sites healthy? What can we do to make this water healthier? If the sight was polluted, where did the pollution come from? What can be done to reduce or eliminate this pollution source?

**EXTENSIONS:**

1) Form cooperative concern committees to address the situation. Using a local map of your water source, brainstorm the possible sources of pollution and determine who to contact with the concerns. Write, call, contact, and follow up with the concerns identified. Encourage students to take action.

2) Repeat the experiments in the opposite season. Compare and contrast their findings.

3) Determine and establish boundaries if the water exploration site is the source of the pollution or if it may come from another spot.

4) Work with the Social Studies teacher to show ways in which political action could be implemented.

5) An Internet search to gather more information.

**RESOURCES:**

Project Wet. Western Regional Environmental Council, 1995.
Creepy Crawlies and the Scientific Method. Sally Stenhouse Kneidel. Fulcrum Publishing, 1993.
Earth Child. Kathryn Sheehan and Mary Waidner. Council Oaks Books, 1991

## Multi-Level Water Study Data

Site Observations

Temperature (Celsius)

Top - _____
Middle - _____
Bottom - _____

Color disc observations

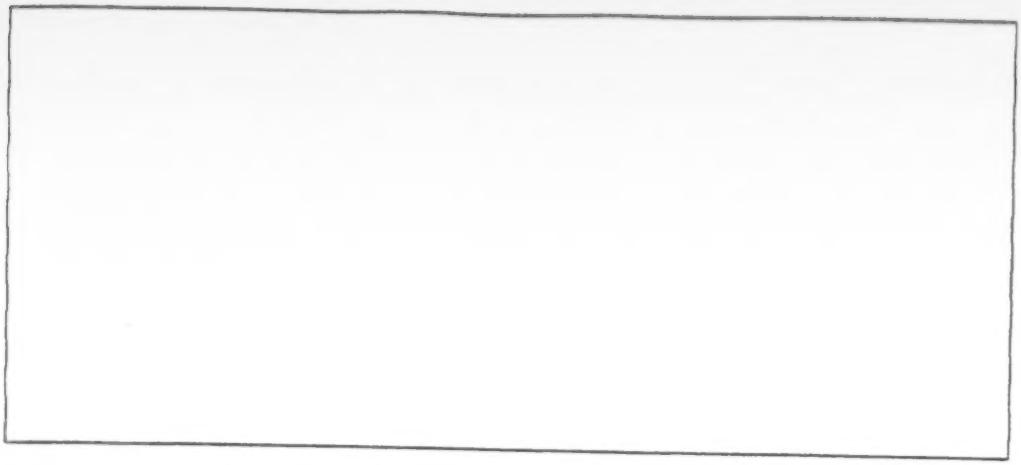
Depth at which each color disappears (use meter stick)

Red - _____
Yellow - _____
Blue - _____
Green - _____

Large animal life observations

125

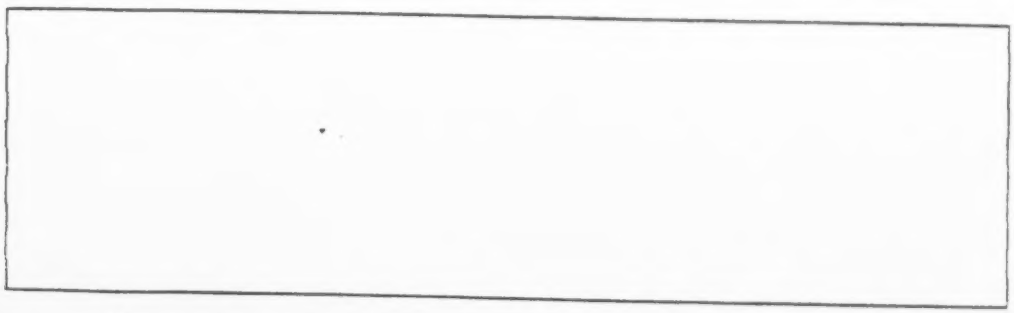
Visible organisms - wet mount



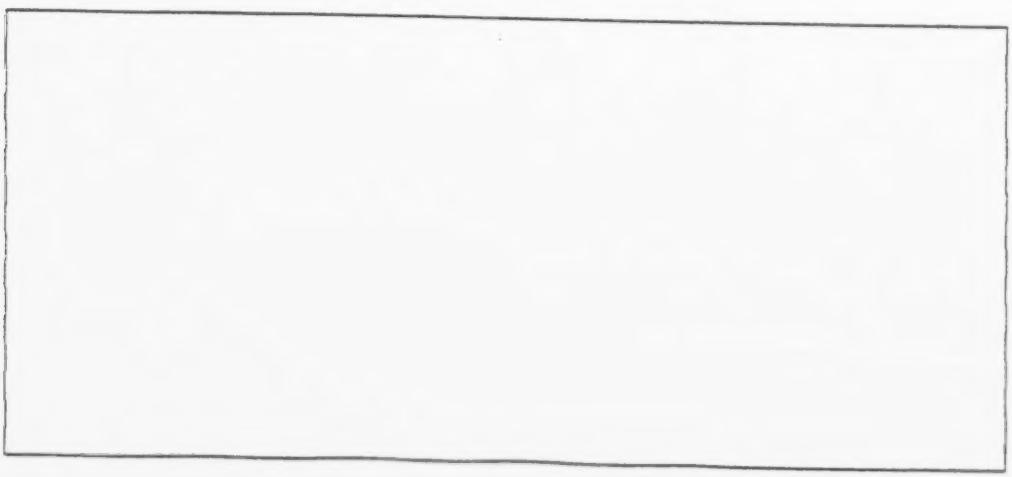
Water samples - pH test

Sample 1 - _____
Sample 2 - _____
Sample 3 - _____

Observations of evaporating water samples



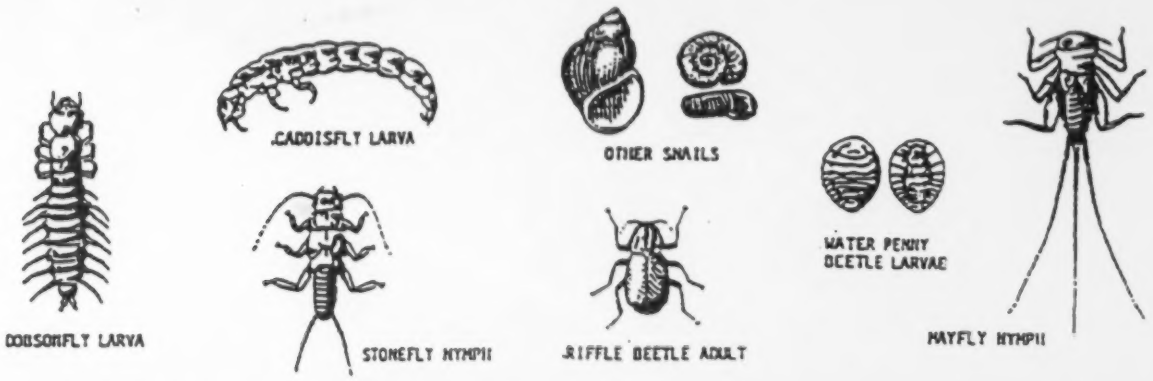
Observations - dry mount



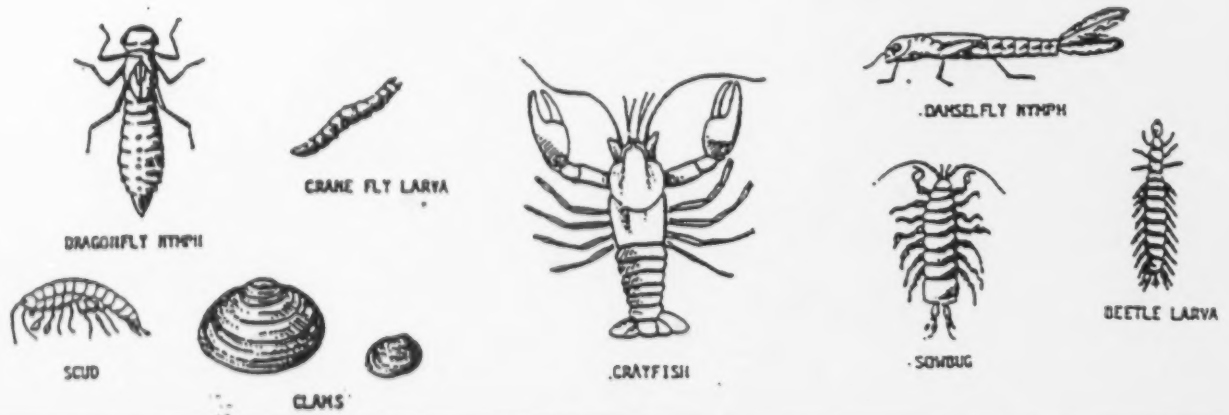
126

# MACROINVERTEBRATE TAXA GROUPS

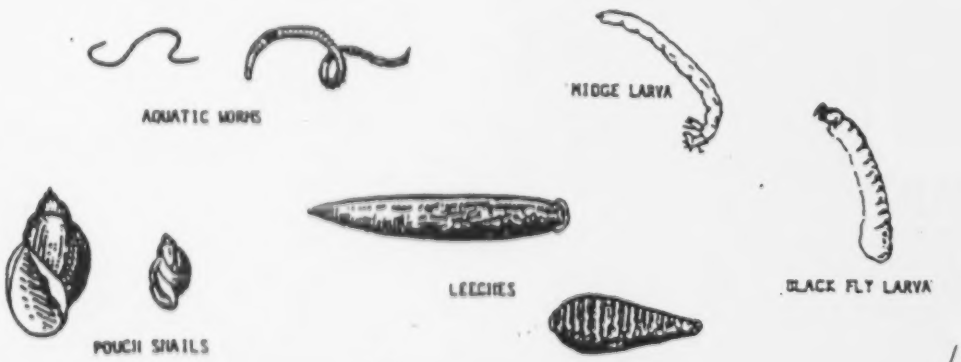
GROUP 1 (*These organisms are generally pollution-intolerant. Their dominanc generally signifies GOOD WATER QUALITY*)




GROUP 2 (*These organisms can exist in a wide range of water quality conditions.*)




GROUP 3 (*These organisms are generally tolerant of pollution. Their dominance usually signifies POOR WATER QUALITY.*)






127

Courtesy of the Ohio Department of Natural Resources

**Camille Schroeck** – Notre Dame Cathedral Latin, Cleveland, OH
**Carolyn Lindstrom** – Beaumont School, Cleveland, OH

## OVERVIEW:

The intent of the lesson is for the student to demonstrate and explain:

1. That water is composed of two elements, each in gaseous form at room temperature.
2. How these two elements can be obtained from water by electrolysis.
3. How one of these two elements, hydrogen, can be used as a fuel.
4. How energy from sunlight might eventually be stored in hydrogen obtained from the electrolysis of water and thus how water could be used as a renewable, non-polluting energy source.

## PREREQUISITES:

**Skills:**

1. lab safety
2. use of lab equipment such as graduated cylinders for measuring

**Knowledge**:

1. concepts of elements and compounds
2. conversion of forms of energy
3. concepts of volume and ratio
4. knowledge of alternate, non-polluting and renewable energy sources
5. conservation of energy

## MATERIALS: (for each group of 2-4 students)

9 volt battery
small plastic cup or 250 ml beaker
plastic spoon
1/2 tsp. baking soda
2 small test tubes (10 x 75 mm)
safety glasses

Students will be able to:

1. Describe the results of running an electric current through water.
2. Use their knowledge of the elements in water to explain their observations.
3. Use their knowledge of volume and ratio to determine experimentally which of the two colorless, odorless gases generated is hydrogen.
4. Explain the energy conversions when either a battery or a solar cell is used for electrolysis of water.
5. Predict the products when the electrolysis of water is reversed, i.e., when hydrogen is burned.
6. Explain why using photovoltaic cells to obtain hydrogen from water and then burning the hydrogen to obtain energy is environmentally preferable to extracting and burning fossil fuels.

## CONNECTIONS TO PROFICIENCY:

**Ninth Grade Math Outcomes:**

1. Solve and use proportions.
2. Select and compute with appropriate standard or metric units to measure, length, area, volume, angles, weight, capacity, time, money temperature.
3. Read the scale on a measurement device to the nearest mark and make interpolations where appropriate.

**Ninth Grade Science Outcomes:**

1. Be able to distinguish between observation and inference given a representation of a scientific situation.
2. Organize data, identify patterns and trends.
3. Draw conclusions and/or recognize a conceptual model based on a given set of data.
4. Identify and apply science safety procedures.
5. Select a device and report data in appropriate units for a specific measurement.
6. Compare renewable and nonrenewable resources and strategies managing them.
7. Relate the effect on an ecosystem to a given environmental change.

## INTRODUCTION:

Teacher will note that we have discussed previously how most substances in our universe are elements or compounds of elements. Atoms of elements combine in exact proportions chemically to form compounds. Students will provide examples of elements and compounds.

Teacher will note that the class has previously studied how energy is converted from one form into another. S/he will have one student give an example.

Students will brainstorm for four or five minutes in groups of four to come up with other types of energy conversions (e.g. chemical to electrical, chemical to heat, electrical to mechanical, mechanical to electrical, etc.) and examples of each type (e.g. burning a candle as a conversion of chemical energy to heat energy). Each group will have one representative list the examples which that group used for one kind of conversion while teacher writes these on overhead.

Teacher indicates that in today's exploration students will examine how electrical energy can be used to create stored chemical energy in the form of the element hydrogen, and how later the hydrogen can be used a fuel.

Students will view a one minute clip from the video "Solar Hydrogen Economy" to review and expand their understanding of the environmental and economical problems associated with the burning of fossil fuel. To give students specific responsibility while viewing, the teacher will have directed them to watch the clip for specific fuels and associated environmental and economical problems discussed.

Teacher will list on the board as students provide verbally the problems associated with fossil fuels. Teacher will raise topic of E√ (Echeck) for cars in the Cleveland area as a local example of these global problems.

Students will help teacher list qualities of an ecologically and economically desirable future fuel. Some probing questions should be asked to make sure students have understood that the "waste" or "pollution" produced by hydrogen fuel is water.

Students will view a seven minute clip for "Solar Hydrogen Economy" presenting hydrogen as a fuel which has the characteristics previously listed on board. To give students specific responsibility while viewing, the teacher will have directed them to watch and remember how hydrogen fits the description they came up with for a desirable fuel.

## EXPLORATION:

The students will perform a scientific exploration: "Can You Make a Futuristic Fuel from Water?" They will set up the experiment, make observations and inferences and predict how this experiment could/could not answer the question in the title by answering the Debriefing (DATA) questions. This exploration is with the lab exploration handout.

## DEBRIEFING:

This DATA form of debriefing will be found on the lab exploration handout. The debriefing should take about 20-30 minutes.

## EXTENTIONS:

Students can explore the future of hydrogen as a fuel by:

1. Searching websites that study the use of photovoltaic cells as a primary
   source of energy in the conversion of water to hydrogen.
   a. Results of this search should be turned in with a 4-column format, titles of the columns being: Potential Use of Hydrogen as a Fuel, Some Problems with this Conversion, Researching Organizations, Website for Information.
2. Writing to the American Hydrogen Association (or visiting their website) for information on hydrogen as a fuel.
3. Writing, phoning, or website searching the EPA for information about the perils of using fossil fuels, and the use of E√ in the Cleveland area.
4. Students individually review the book *Hannah and Sarah's Hydrobile (1-850-267-3221),* describing its contents and evaluating for what age student the story and information seem appropriate.
5. In groups of 4, students investigate photovoltaic, geothermal, biomass, and trash as fuel and other alternatives to fossil fuels and report orally with appropriate visuals on four benefits and four drawbacks of each energy source.
   References should include at least two of the following:
   a) *The Sun's Joules* CD-ROM, Solstice. (1-800-346-0104)
   b) Websites listed in resource section.
   c) Relevant books or periodicals
5. Students obtain information on the perils of using fossil fuels by writing or phoning The Clean Air Conservancy and the EPA and then present this information in a collage or other graphic representation.

6. Using links on the Internet and starting from specified websites like those resources listed, pairs of students are to find a total of 25 private organizations, government agencies, large corporations or small businesses involved in research on replacing fossil fuels with renewable, non-polluting energy sources. These 25 organizations, businesses or agencies should be listed with following information:
    a. Name, URL, Type of Renewable Energy Source Investigating or Promoting, Fossil Fuel This Source Will Replace.

## Resources:

**Books:**


*Quick Energy and Beyond--Ideas for the 90's*--Colorado Energy and Resource Educators, Inc. , 1991, p. 28-29.

*Science Projects in Renewable Energy and Energy Efficiency,* American Solar Energy Society, 1991, p. 35.

*About Solar Energy,* Scriptographic Booklet, Channing L. Bete Co., Inc., South Deerfield, MO, 1992

*Environmental Science Activities Kit,* Michael L. Roa., The Center for Applied Research in Education, West Nyack, NY. 10995., p. 238-243


**Internet and Phone Contacts:**

The Clean Air Conservancy
1360 W. 9th St., Suite 400
216-523-111, 1-800-2-Buy Air (228-9247) - Kevin Snape
email: clean air@EBNL.com

EPA Public Information
1-800-331-9477
Ohio EPA: 1-800-686-6330 Cleveland EPA: 1-216-835-5200

American Hydrogen Association
1739 West 7th Ave
Mesa, Arizona 85202-1906
email: aha@getnet.com http://www.clean-air.org

American Solar Energy Society http://www.ases.org/solar/

Earth's Biggest Environmental Search Engine
http://www.webdirectory.com

**Video:**

"Solar-Hydrogen Economy" from the American Hydrogen Society. This video shows how the use of solar power and hydrogen fuel can help solve environmental problems,such as global warming, acid rain, ozone depletion, and urban air pollution, 1992.
Source: Environmental Science Energy, Billy Goodman, et al., Globe Fearon

**Background Information (for teacher)**


1. "Facts that Everyone Should Know" by Roy McAlister, American Hydrogen Assoc.
2. "Solar Electricity", p. 10., *About Solar Energy,* Scriptographic Booklet.
2. "Activity 25: Energy Alternatives". *Environmental Science Activities Kit,* Michael L. Roa. The Center for Applied Research in Education, West Nyack NY, 10995, p. 238-243.
3. "Photovoltaics and Photoelectrochemistry", *Science Projects in Renewable Energy and Energy Efficiency,* American Solar Energy Society, 1991, p. 35
5. *Hydrogen Today,* The American Hydrogen Association, Vol 8, No.2, 1997.
6. *Renewable Hydrogen Energy for a Better Environment.,* The American Hydrogen Assoc.
7. Membership application to the American Hydrogen Association.
8. Background sheet for the lab "Can you Make a Futuristic Fuel from Water?", Colorado ERE, p. 28

## Can You Make a Futuristic Fuel** from Water?

Hydrogen has been called the "fuel of the future." It is a flammable gas that can power cars, buses and even jets. Hydrogen can even be used like natural gas to heat homes and fuel industrial processes. The problem is that hydrogen does not occur naturally on earth. Water is abundant and its molecules contain both hydrogen and oxygen. In this experiment, you will use the electrical energy from a battery to break apart water molecules into hydrogen and oxygen.

Materials: (for each group of 2-4 students)

- safety goggles
- 9 volt battery
- small plastic cup (or 250 ml beaker)
- plastic spoon
- 1/2 tsp. baking soda ($NaHCO_3$)
- 2 small test tubes (10 x 75mm)
- water

Procedure:

1. Put on your safety goggles and half fill the plastic cup (or beaker) with water. Add 1/2 teaspoon of baking soda ($NaHCO_3$). Stir.
2. Fill both test tubes with the water from the cup. One by one, place your finger over the open end of the test tubes and turn them upside down in the cup so that both tubes are filled with water and have no air trapped inside.
3. Place the 9 volt battery into the water-filled cup. Place the inverted, water-filled test tubes over the battery terminals. DO NOT raise the test tubes out of the water.
4. Allow the reaction to proceed for about 5 minutes or until observations about the amount of gases collected in the test tubes can be noted.
5. Write down your observations.
6. With your lab partners, answer the DATA debriefing questions.

**This lab is an adaptation from "Can You Make a Futuristic Fuel From Water?", *Quick Energy and Beyond--Ideas for the 90's*, Colorado Energy and Resource Educators, Ind., 1991, p. 29.

Students will debrief first in writing with lab partner. They then will join in a whole class discussion led by the teacher.

Describe:

What did you see at the anode and cathode?
Which appeared to have more gas, the anode or the cathode?
What was the ratio of the amounts of the gases to the other?

Analyze:

Which gas can you conclude is the hydrogen? Why?
What was causing the water to break apart into hydrogen and oxygen?
Were we putting energy in or taking it out in this electrolysis process?
Make a diagram or sketch using a yields arrow to describe what was happening in this chemical process.
If we were to go backwards and put the hydrogen and oxygen back together to form water, what does your diagram from above say we should also get in the process besides the water?
Combining hydrogen and oxygen to form water can be called "burning hydrogen". Why is that a reasonable description?
When we burn hydrogen as a fuel we are primarily interested in getting energy.
What is the "waste product" when we burn hydrogen to get energy?
Why do you think hydrogen is described as a clean burning fuel.?

Transfer:

In this experiment we used chemical energy from a battery to produce electrical energy for the electrolysis. What renewable source of energy that we discussed could we have used in place of the polluting batteries?
Solar or photovoltaic cells are made of silicon (which comes from sand) and some metal. Why can photovoltaic cells be called a cleaner source of energy than present day batteries?

Apply:

Individually but with some consultation make two lists. The first one should be of all the ingredients to produce hydrogen from electrolysis using photovoltaic cells. The second list should have all the products you get when you "burn hydrogen" to get energy.
Make a picture or flow diagram that shows how both lists fit together to describe energy production that is low in pollution and uses renewable or low cost resources.
Describe at least three ways in which the use of hydrogen as a fuel is economically and/or environmentally better than burning a fossil fuel for energy.
Formulate four questions you still have about the process of getting energy from the sun using hydrogen.
Explain one way this hydrogen fuel can be used to replace a fossil fuel.

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**Katherine Brown** – Shaker Heights High School, Shaker Heights, OH
**Bernadette Manzo** – Cleveland Extension High School, Cleveland, OH

**OVERVIEW:**

In this lesson students will simulate the production of acid rain from coal and observe the effects of acid rain on plant growth.

**PREREQUISITE:**

SKILLS - measuring pH, writing lab report, caring for plants, using lab safety skills when working with flammable materials

KNOWLEDGE - concept of acids, bases and neutral solutions; interpretation of pH scale

**MATERIALS:**

Whole class: Video: ACID RAIN.

**LAB I, Simulation of acid rain production.**

Per group ( 4 students): sample of anthracite (may be obtained from American Coal Foundation); source of ignition (such as a large wooden kitchen match, Bunsen burner, alcohol burner); wide mouth glass bottle; stopper; metal spoon with the handle bent at a right angle to the bowl; 10 mL of water; pH paper; well tray or spot plate.

**LAB II, Simulation of the effects of acid rain on plant growth.**

Per group(4 students): established young plants in individual containers; samples of collected rain water, bottled water, acidic water (teacher provided made of 10 mL of an available acid such as vinegar added to 1000 mL of bottled water), acidic water that the students have neutralized; graduated cylinder; balance; metric ruler.

**ANTICIPATED STUDENT OUTCOMES:**

Students will simulate the formation of acid rain.
Students will measure the effects of acid rain on plant growth.
Students will compare the effects on plant growth of water samples that vary in pH.
Students will analyze the results and draw conclusions based on collected data.

**CONNECTIONS TO PROFICIENCY TEST:**

Eight of the Ninth Grade Science Outcomes will be addressed through this lesson. Objectives 2 through 7 in the Nature of Science category are highlighted, as well as #14 in The Physical Setting category and #22 in the Societal Perspective group. Please refer to the attached copy of the Ohio High School Proficiency Outcomes for Mathematics and Science.

**INTRODUCTION:** (15 minutes)

Descriptors of acid rain will be solicited from students and written on the board. The class will be invited to compare ideas to those presented in the video. A clip from the video, ACID RAIN, will be shown to the class. The initial footage illustrates rather dramatic environmental damage caused from acid rain. This will be followed by another short clip from the same video which clearly discusses the consumption of fossil fuels as the cause of this problem. At the conclusion of these segments, students will be told that this topic is what they will be investigating in class.

**EXPLORATION:**

LAB I: (30 minutes)

Divide the students into groups of four, assigning each a task.
Each group should collect the necessary materials as listed in materials sections for LAB I.
Place a small sample of distilled water in one of the wells of the well tray.
Test the distilled water for pH using pH paper.
Put 10 mL of distilled water in the bottom of the wide mouth bottle.
Place a sample of coal on the spoon and ignite.
Quickly place the burning coal sample in the bottle without allowing it to touch the water at the bottom. AND STOPPER IT.
Allow the coal sample to burn itself out in the bottle.
Remove the spoon and sample.

Replace the stopper in the bottle and shake the smoke filled bottle until all of the smoke is dissolved in the water.
Put a small sample of the water from the bottle in a well of the well tray.
Test the pH of the sample.
Make sure all results are recorded in the basic lab write-up format.

LAB II: (set-up 30 minutes)

Students maintain the same lab groups.
Each group collects the necessary materials as listed in material section for LAB II
To make the neutralized water, baking soda will be added in 1/4 tsp. increments until the pH paper tests neutral.
Four plants will be used for each group. These will be labeled to indicate the type of water being used.
Initial observations will be made of the mass of the plant in the container, the height of the plant and the general appearance of the plant.
For the next four weeks, group members will take turns in completing the necessary tasks. These include: daily watering of each plant using 20 mL per day of each water sample, recording daily observations of general plant appearance, daily measuring height of each plant, weekly weighing of the plant.

**DEBRIEFING:**

LAB I: (15 minutes)

The students will be regrouped so that one representative from each group is a member of the new group. (Jigsaw strategy). The students will share the results of LAB I orally with each other. Differences in results will be discussed and possible reasons for the differences will be explored.

LAB II: (20 minutes)

The students will share their plant growth observations of the last four weeks via a poster session. The design of the posters will be determined by the consensus of the group.

**EXTENSIONS:** (4 weeks)

Students will research careers that are connected to the search for solutions to problems associated with acid rain.

Students will be given the optional assignment of constructing a photo essay of their community, or the city, which depict the causes/effects of acid rain.

**RESOURCES:**

Tyson, P. (1992). ACID RAIN, EARTH AT RISK. New York: Chelsea House Publishers. Global Issues Resource Center, CCC- East1

ACID RAIN (1993), 30 minutes, Earth at Risk Series, Schlessinger Video Productions. Global Issues Resource Center, CCC-East 1

http://qlink.queensu.ca/~4lrm4/effect2.htm

American Coal Foundation. (1995). ACF MATERIALS ORDER FORM. Washington,D.C.

**BACKGROUND INFORMATION:**

Generally, if the pH of precipitation has a value of less than 5.6, it is considered to be acidic. There are many causes of acid rain, but one of the main ones is sulphur dioxide. Although some natural sources release sulphur dioxide, the burning of fossil fuels like coal and oil are responsible for about one half of the emissions of this gas. There are numerous negative effects of acid rain on the environment. A detailed examination of these effects is included in the attached handout section. In addition, the information can be found on the Internet at the following address: http://qlink.queensu.ca/~4lrm4/effect2.htm

**HANDOUTS:**

1. Information packet on Acid Rain: The ABC's of Acid Rain, by Michelle Cheng and Lisa Mori.

2. How Coal is Formed from American Coal Foundation. Also, coal samples may be ordered from American Coal Foundation.

# How Coal Is Formed

Coal is classified by geologists as a mineral. But most minerals, like salt or stone or iron ore, were formed millions of years ago by inorganic matter, or substances that were never alive. Coal, on the other hand, came from organic matter—plants that lived about 300 million years ago.

During the Carboniferous Period, which is the name given to the time when coal was formed, the earth was covered with huge swampy forests where plants—giant ferns, reeds and mosses—grew taller than our tallest trees today.

As the plants grew, some died and fell into the swamp waters. New plants grew up to take their places and when these died still more grew. In time, there was a thick layer of dead plants rotting in the swamp.

The surface of the earth changed and water and dirt washed in, stopping the decaying process. More plants grew up, but they too died and fell, forming separate layers. After millions of years many layers had formed, one on top of the other.

The weight of the top layers and the water and dirt packed down the lower layers of plant matter. Heat and pressure produced chemical and physical changes in the plant layers which forced out oxygen and left rich carbon deposits. In time, material that had been plants became coal.

Geologists say that it may have taken a layer of plants 20 feet thick to form a coal seam one foot thick. Of course, coal seams vary in thickness. In some places they may be only a few inches, but in others they may range from a few feet up to more than 100 feet.

We know that coal was made from plants because we often find fossils, or impressions, of these early plants in coal. Fossils can be in the shape of stumps, leaves, seeds or other plant parts, or they even may be whole plants.

That is why some people call coal "buried sunlight." The plants from which coal was formed had absorbed energy from the sun. As the plants decayed, some of the energy escaped but most of it remained. Today, when we burn coal we use what is left of the sun's energy of 300 million years ago.

Coals are classified into three main ranks, or kinds: lignite, bituminous coal and anthracite. These classifications are based on the amount of carbon, oxygen and hydrogen present in the coal. These amounts can vary with the location of the coal bed, the kind of plants that formed the coal and the degree of change brought about by heat and pressure.

**Peat,** while it is not coal, is the first product in the coal scale. The plants changed first into peat and then into the ranks of coal.

Peat is brown, crumbly, lightweight and spongy in texture. You may see part of the original plants which formed it—roots, leaves and bark.

Peat is dug and processed for sale in 36 states, but three-fourths of all peat is produced in seven states: Michigan, Pennsylvania, New Jersey, Indiana, Illinois, Colorado and California.

Most of the peat produced in the United States is used to improve the soils on lawns, golf courses, gardens, in greenhouses and nurseries. It is also used as packing material for plants, and shrubs, as insulating material, as an ingredient in fertilizers and as litter for livestock. In many countries in Europe, such as Ireland, peat is burned as fuel.

Peat is being formed in the United States even today in the Dismal Swamp in Virginia and North Carolina, the Everglades in southern Florida and in many other small bogs and coastal swamps.

**Lignite** is the lowest rank of coal—which means that it has the lowest heat content of the three ranks of coal and was formed from peat. Perhaps you can still see some of the peaty structure in the sample.

Although lignite is more solid than peat, it crumbles when shipped long distances, so it usually is used close to the mine. It has a high moisture content, too, but dries out when exposed to air.

Most of the lignite in the United States is in North and South Dakota, Montana and Texas. Lignite is used principally to produce electricity at power plants.

**Bituminous coal,** or soft coal as it is sometimes called, was formed by added heat and pressure on lignite. Bituminous coal appears smooth when you first see it, but look closer and you may see it is in layers. You may see a shiny, glass-like layer in coal known as vitrain, or wood that was preserved in water. Another band, dull and grayish, is clarain, formed from fine plant debris. A third, charcoal-like layer is fusain, made from chemically changed wood.

By far the most abundant kind is bituminous coal. It is found in many of our states in both eastern and western parts of the country.

More than 80 percent of the bituminous coal produced in the United States is burned to generate elec-



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tricity. Other major coal users are the cement, food paper, automobile, textile and plastic industries. Another important industrial use is to provide coke for iron and steel industries.

Bituminous coal derivatives, or by-products, can be changed into many different chemicals from which we can make paint, nylon, aspirin and many other items.

**Anthracite,** the final stage of coal-making, is often called hard coal. It is deep black and looks almost metallic because it is brilliantly glossy. The primary market for anthracite is for heating homes.

Nearly all of the anthracite in the United States is in Pennsylvania, but there are some small beds in Idaho, Nevada, Utah, Arkansas, Tennessee, Virginia, Washington, Rhode Island and Massachusetts.

The main market for anthracite is for heating homes.

Coal is the most abundant fossil fuel available to man, and while it has been a major energy source for over two centuries, experts say there is enough coal to last many more centuries.

Almost one-third of the world's coal supply is in the United States where, according to the U.S. Geological Survey, it makes up 74 percent of the total mineral fuel supply.

Coal mining presently takes place in 27 states. The states with the largest potentially mineable reserves are Montana, Wyoming, Illinois, West Virginia, Kentucky and Pennsylvania.

AMERICAN COAL FOUNDATION

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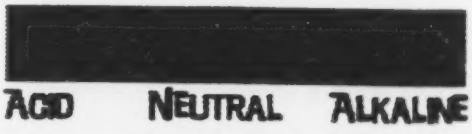
## TABLE OF CONTENTS

- The Acid Rain Definition
- What Causes Acid Rain?
- The Effects of Acid Rain:
  - Effect on Trees and Soils
  - Effect on Lakes and Aquatic Systems
  - Effect on Materials
  - Effect on Atmosphere
  - Effect on Architecture
  - Effect on Humans
- Formation of Acids in the Atmosphere
- Reducing Emissions
- Links to Other Acid Rain Sites
- List of Useful Sources

Please send feedback to 4lrm4@qlink.queensu.ca!!

# ACID RAIN - A DEFINITION

Acidity is measured using a pH scale, with the number 7 being neutral. Consequently, a substance with a pH value of less than 7 is acidic, while one of a value greater than 7 is basic. It is also worthwhile to note that the pH scale is logarithmic; that is, a substance of pH of 6 is 10 times more acidic than another with a pH of 7. Generally, the pH of 5.6 has been used as the baseline in identifying acid rain, although there has been much debate over the acceptance of this value. Interestingly enough, a pH of 5.6 is the pH value of carbon dioxide in equilibrium with distilled water. Hence, acid ran is defined as any rainfall that has an acidity level beyond what is expected in non-polluted rainfall. In essence, any precipitation that has a pH value of less than 5.6 is considered to be acid precipitation. The following is a visual illustration of the pH scale:



***Readings of pH 2.4—as acidic as vinegar—were recorded during storms in New England. During one particularly acid summer storm, rain falling on a lime-green automobile leached away the yellow in the green paint, leaving blue raindrop -shaped spots onthe car.***

# WHAT CAUSES ACID RAIN?

One of the main causes of acid rain is sulphur dioxide. Natural sources which emit this gas are volcanoes, sea spray , rotting vegetation and plankton. However, the burning of fossil fuels, such as coal and oil, are largely to be blamed for approximately half of the emissions of this gas in the world. When sulphur dioxide reaches the atmosphere, it oxidizes to first form a sulphate ion. It then becomes sulphuric acid as it joins with hydrogen atoms in the air and falls back down to earth. Oxidation occurs the most in clouds and especially in heavily polluted air where other compounds such as ammonia and ozone help to catalyze the reaction, converting more sulphur dioxide to sulphuric acid. However, not all of the sulphur dioxide is converted to sulphuric acid. In fact, a substantial amount can float up into the atmosphere, move over to another area and return to earth unconverted. The following are the stoichiometric equations for the formation of sulphuric acid:

$S$ (in coal) $+ O_2 \rightarrow SO_2$

$2\ SO_2 + O_2 \rightarrow 2\ SO_3$

$SO_3 + H_2O \rightarrow H_2SO_4$

Nitric oxide and nitric dioxide are also components of acid rain. Its sources are mainly from power stations and exhaust fumes. Like sulphur dioxide, these nitrogen oxides rise into the atmosphere and are oxidized in clouds to form nitric acid. These reactions are also catalysed in heavily polluted clouds where iron, manganese, ammonia and hydrogen peroxide are present.*

The chart below indicates the pH levels of wet deposition over time at the corresponding provinces in Canada. Accompanied with it are charts of emmisions over time in Canada compared with the United

# WHAT CAUSES ACID RAIN?

One of the main causes of acid rain is sulphur dioxide. Natural sources which emit this gas are volcanoes, sea spray , rotting vegetation and plankton. However, the burning of fossil fuels, such as coal and oil, are largely to be blamed for approximately half of the emissions of this gas in the world. When sulphur dioxide reaches the atmosphere, it oxidizes to first form a sulphate ion. It then becomes sulphuric acid as it joins with hydrogen atoms in the air and falls back down to earth. Oxidation occurs the most in clouds and especially in heavily polluted air where other compounds such as ammonia and ozone help to catalyze the reaction, converting more sulphur dioxide to sulphuric acid. However, not all of the sulphur dioxide is converted to sulphuric acid. In fact, a substantial amount can float up into the atmosphere, move over to another area and return to earth unconverted. The following are the stoichiometric equations for the formation of sulphuric acid:

S (in coal) + $O_2 \rightarrow SO_2$

2 $SO_2$ + $O_2 \rightarrow$ 2 $SO_3$

$SO_3 \rightarrow$ + $H_2O$ $H_2SO_4$

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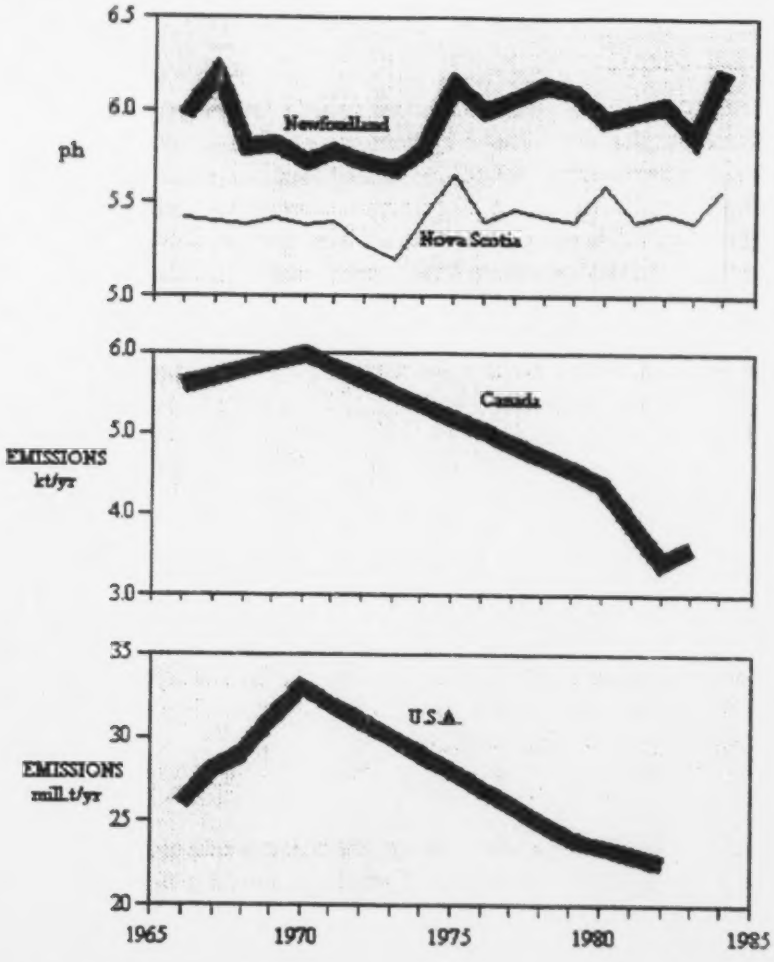
*Click Here to View Source(s)

The chart below indicates the pH levels of wet deposition over time at the corresponding provinces in Canada. Accompanied with it are charts of emmisions over time in Canada compared with the United States.

As observed, although the level of emissions in both Canada and the United States have been reduced over the years, the pH level measured (for Canada - namely Nova Scotia and Newfoundland) has not reflected similar results.

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# Converting $NO_x$ and $SO_2$ to Acids

The acidity of acid precipitation is dependent not only on emission levels, but also on the chemical mixtures with which $SO_2$ and $NO_x$ interact in the atmosphere. The formation of sulfuric and nitric/nitrous acid is a complex process involving several chemical reactions. It is important to consider both solution and gas phase chemistries in the conversion process.

## $SO_2$:

### Gas Phase

There are several potential reactions that can contribute to the oxidation of sulfur dioxide in the atmosphere, each with varying success. One possibility is photooxidation of $SO_2$ by ultraviolet light. Light in this region of the electromagnetic spectrum has the potential to excite the molecule and lead to the subsequent oxidation by $O_2$. This reaction was found to be an unimportant contributor to the formation of sulfuric acid. A second possibility is the reaction of sulfur dioxide with atmospheric oxygen by the following reactions:

1) $2SO_2 + O_2 \rightarrow 2SO_3$

2) $SO_3 + H_2O \rightarrow H_2SO_4$

Reaction 2 occurs quickly, therefore the formation of $SO_3$ in the moist atmosphere is assumed to lead to the formation of sulfuric acid. However, reaction 1 is very slow in the absence of a catalyst, therefore this is also not a significant contributor. There are several other potential contributors including oxidation by products of alkene-ozone reactions, oxidation by reactions of $N_xO_y$ species, oxidation by reactive oxygen transients, and oxidation by peroxy radicals. All of these reactions, however, prove to be insignificant for varying reasons (ie- too slow). Although each of these reactions may make a minor contribution to the oxidation of $SO_2$, there is thought to be only one significant reaction. The reaction occurs as follows:

$HO + SO_2(+M) \rightarrow HOSO_2(+M)$

This reaction occurs at an appreciable rate and is thought to be the sole contributor to the oxidation of $SO_2$ in the atmosphere. The hydroxy radical is produced by the photodecomposition of ozone and is considered to be highly reactive with many species.

### Aqueous Phase

In the aqueous phase, sulfur dioxide exists as three species:

$[S(IV)] \rightarrow [SO_2(aq)] + [HSO_3^-] + [SO_3^{2-}]$

This dissociation occurs by a two-fold process:

1) $SO_2(aq) \rightarrow H^+ + HSO_3^-$

2) $HSO_3^-(aq) \rightarrow H^+ + SO_3^{2-}$

The establishment of the above equilibrium is dependent upon such things as pH, droplet size, the "sticking coefficient" for $SO_2$ on water, etc.

The oxidation of aqueous $SO_2$ by molecular oxygen relies on a metal catalyst such as $Fe^{3+}$ or $Mn^{2+}$ or a combination of the two. Oxidation by ozone, however, is a more appreciable process because it does not require a catalyst and it is $10^{-8}$ - $10^{-9}$ more abundant in the atmosphere than molecular oxygen. The dominant oxidation process occurs by hydrogen peroxide (formed in the gas phase from free radicals). The reaction involves the formation of an intermediate ($A^+$), possibly a peroxymonosulfurous acid ion, and proceeds as follows:

1) $HSO_3^- + H_2O_2 \rightarrow A^+ + H_2O$

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2) $A^- + H^+ \rightarrow H_2SO_3$

## $NO_x$:

### Gas Phase

As with $SO_2$, the principal contributor to the formation of nitric acid is the reaction with hydroxy radicals. These radicals are highly reactive and abundant in the atmosphere. The reaction proceeds as follows:

$HO + NO_2 (+M) \rightarrow HONO_2(+M)$

There are several other existing possibilites such as oxidation by atmospheric oxygen, however none occur at a substantial rate in the atmosphere to be significant contributors to the formation of nitric acid.

### Aqueous Phase

There are three equilibria to consider in the aqueous oxidation of $No_x$:

1. $2NO_2(g) + H_2O(l) \rightarrow 2H^+ + NO_3^- + NO_2^-$

2. $NO(g) + NO_2(g) + H_2O(l) \rightarrow 2H^+ + 2NO_2^-$

3. $3NO_2(g) + H_2O(l) \rightarrow 2H^+ + 2NO_3^- + NO(g)$

These reactions are limited by their dependence upon the partial pressures of $NO_x$ present in the atmosphere, and the low solubility of $NO_x$. Potential for increase in reaction rate exists with the use of metal catalysts, similar to those used in the aqueous oxidation of $SO_2$.

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# Other Acid Rain Links

- Acid Rain Program: http://www.epa.gov/docs/acidrain/ardhome.html
- Econet-Acid Rain:http://www.econet.apc.org/acidrain/
- New Brunswick Precipitation Monitoring Program: http://www.gov.nb.ca/environm/operatin/air/acidrain.htm
- FAQ on Acid Rain: http://www.ns.doe.ca/aeb/ssd/acid/acidfaq.html
- Atmospheric Science-Acid Deposition: http://atlenv.bed.ns.doe.ca/aeb/ssd/acid/index.html
- 21 Envirofacts-Acid Rain: http://www.gem.co.za/enviro/21.htm
- Plain English Guide To The Clean Air Act: http://www.epa.gov/oar/oaqps/peg_caa/pegcaaos.html
- Geothermal And The Environment-Acid Rain: http://solstice.crest.org/renewables/re-kiosk/geothermal/environment/ ar.shtml
- Environment Canada-Global Site: http://www.ec.gc.ca

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